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SOME DETERMINANTS OF CONTRACT PRICES IN DEFENSE PROCUREMENT

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SOME DETERMINANTS OF CONTRACT PRICES IN DEFENSE PROCUREMENT

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This research memorandum reports results of exploratory research on models and techniques used in estimating the effects of competition as well as several other variables in weapon system production contract prices. The purpose of this effort was to examine the use of pooled cross-section, time-series data in modeling the acquisition process. The approach expresses price as a function of a number of variables that describe the technical, institutional, and behavioral characteristics of the acquisition program and its environment. The approach is not tied specifically to competitive acquisitions; however, the primary aim of the research was to examine models used to estimate the effects of competition.

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INTRODUCTION

This paper, one of a series, reports results of exploratory research on models and techniques used in estimating the effects of competition in defense procurement [1,2]. In [1], Berg, Dennis, and Jondrow noted that the models of competition in defense procurement found in the literature used, as their basic construct, the shift and rotation in a learning curve to portray and estimate the effects of competition on production unit costs or prices. This learning curve-based construct is referred to as the Price Improvement Curve (PIC). The authors concluded that models used in the literature were too narrowly based on cumulative production quantity and production rate as the driving variables used to forecast production pricing behavior. They hypothesized other variables as significant determinants of production pricing behavior by competing contractors. A further hypothesis held that a more complete model of the production competiton process and its effects on prices would include a broader range of technical factors as well as institutional and behavioral factors that would determine price. Although the literature was rich in suggestions for possibly significant variables, only one research report, [4], discussed empirical exploration of a variable other than cumulative production quantity or production rate.

In [2], Berg and Quinn reviewed current cost analysis practices in the Navy for estimating the effects of production competition on contract lot prices. Although the current practices were found to be improved in several respects over those in the literature, they also used a narrow set of variables. In particular, institutional and behaviorial factors such as the elements of the competitive strategy pursued or the market conditions and company situations were not given explicit treatment in the analyses of competitive effects on prices.

This paper reports the results of an exploratory investigation into the broader determinants of production contract prices in weapons acquisition. The purpose of this effort was to examine the use of pooled cross-section, time-series data in modeling the aquisition process. The approach expresses price as a function of a number of variables that describe the technical, institutional, and behavioral characteristics of the acquisition program and its environment. Although the approach is not tied specifically to competitive acquisitions, the genesis of the research was an examination of models used to estimate the effects of competition and the inclusion of competitive procurements is an important part of this effort.

The next section briefly describes the background that led to this research. The following sections discuss theoretical considerations based on the structure of the defense contracting environment, the data used in the analysis, and the empirical model and specifications used in this research. The last two sections present results and conclusions.

BACKGROUND

In evaluating the effects of competition the typical approach has been to analyze each competed program in isolation. Integration of the analyses across programs, when performed, has been subjective. The result of this one-at-a-time approach is that quantitative analysis is based on a limited number of time-series observations on price [1], so that only a small number of variables can be considered in any statistical evaluation. This limitation (or degrees of freedom) is further compounded by the need to separate the observations into pre- and post-competition periods so that the pre- and post-competition prices can be compared. This separation of data reduces the effective number of observations and consequently the number of variables that can be considered as determinants of price in that program.

One partial solution for the degrees-of-freedom problem may be to add a cross-section perspective to estimate the prices and to evaluate the *effects* of competition. The cross-section approach pools data from different programs to increase the available observations, while simultaneously adding variables that distinguish different programs. If a sufficient number of programs are available, the number of observations will rise more quickly than the number of variables, and the degrees-of-freedom problem can be reduced.

In addition to the potential statistical benefits, adding cross-section perspective provides the potential for further insights into the price formation process in defense procurement. The literature on competition includes a discussion of various screening criteria [1]. These criteria are typically related to programmatic, institutional, or industrial considerations, both quantitative and qualitative.[1] By including these screening criteria as variables in a model of price formation, the different programs can be distinguished and the relative importance of the criteria established.

Two specific branch studies were used to investigate the pooled cross-section, time-series approach. Although both branch studies use a sample of tactical missiles, they differ in the particular data used and in its source. One study focuses on the total program using budget and industry-level data from public sources. The other study, focusing on contract prices and firm-specific data, is reported here.

[1] Some examples of these criteria: total program quantity, the willingness of Congress to fund competition, and the state of industry demand.

THEORETICAL CONSIDERATIONS

A search for a theoretical basis for the analysis of the procurement of major weapons systems leads, almost invariably, to the theory of bilateral monopoly, an exchange process in which there is a single buyer of a product and a single seller. Unfortunately, as Scherer points out, "The theory of bilateral monopoly is indeterminate with a vengeance" [17, p. 299]. For major weapons systems, even so-called competitive acquisitions are more accurately described, at least on the sellers' side, as structurally duopolistic or oligopolistic.[2] Given the inherent monopsonistic nature of the procurement process for major weapons systems, introducing duopoly may only serve to aggravate the indeterminacy at least, as Scherer so aptly states, "..., in the narrow sense that one cannot forge unique and compelling mechanistic links from cost and demand conditions to price equilibria" [17, p. 152].

Does this indeterminacy imply that there is no solution, no applicable model, or no approach to the analyses of bilateral monopoly and oligopoly and, consequently, to the analysis of defense procurement? Scherer addresses this question as well, stating:

> A more constructive interpretation is this: To make workable predictions we need a theory much richer than the received theories of pure competition and pure monopoly, including variables irrelevant to those polar cases. In our quest for a realistic oligopoly theory we must acquire Professor Mason's "ticket of admission to institutional economics,"[3] at the same time retaining the more sharply honed tools with which economic theorists have traditionally worked. We must not expect too much, however. The most that can be hoped for is a kind of soft determinism: predictions correct on the average, but subject to occasionally substantial errors [17, p. 152].

The search for a richer theory starts with recognizing that, in economic models, price depends on conditions in three broad catagories:

- Behavioral—decision rules based on the goals/objectives of the agents
- Institutional—the rules and conditions that constrain agent behavior
- Technological—methods of production and consumption.

[2]These descriptions arise from the economic tradition of classifying market structures by counting the number of participants. One seller is a monopoly. Two or a few sellers represent, respectively, duopoly and oligopoly, and many sellers is representative of a competitive structure. Analagous descriptions of buyer structure are, in order, monopsony, duopsony, oligopsony, and competitive.

[3]Edward S. Mason, *Economic Concentration and the Monopoly Problem* (Cambridge, Mass.: Harvard University Press, 1957), p. 60.

The extent to which conditions in these catagories can be specified will influence the degree of determinancy in the models.

For example, economic models of perfect competition describe an impersonal environment in which the buyers and sellers need only know their own technologies[4] and the publicly available price information to make their decisions. In these competitive models agents are unable to gain an advantage by withholding information on their willingness to buy or sell at different prices. Consequently, publicly available prices and price histories contain all the information required for decision making. Given the behavioral and technical assumptions, the well-defined institutional structure of the pure competition model results in clearly defined equilibrium prices for competitive markets.

The irrelevance of any information except price also holds for consumers in the classical pure monopoly. Here, the seller's ability to extract economic profits arises because the individual consumer has no leverage and cannot gain by withholding information on his preferences. No leverage exists because the individual consumer does not have any identifiable effect on the monopolist. Again, the well-defined institutional structure of the classical pure monopoly provides an unambiguous equilibrium price.

The indeterminacy of the oligopoly and bilateral monopoly models in economic theory arises, in part, because no well-defined institutional structure exists that provides incentives for the buyers or sellers to reveal their true preferences.[5] Because misrepresenting preferences may pay off for a participant, the outcomes of these models depend on the assumed institutions and the payoffs associated with various representations of preferences.

INSTITUTIONAL STRUCTURE: MODELS AND APPLICATION IN DEFENSE

The central characteristics of the institutional structure of defense procurement are reflected in the models used to estimate the costs of a prospective weapon system and those models used to determine whether a contractor's price proposal is fair and reasonable.

The learning, or experience, curve provides the conceptual foundation for defense price analysis. As the following discussion will show, the models applied in the evaluation of procurement costs are all variations/derivations of the basic learning curve. The learning curve concept originated with the observation in the airframe industry that the number

[4] In this case technologies refers to the consumer's preference structure and the seller's production function.

[5] In perfect competition the key element is the inability of a single individual, either buyer or seller, to affect the market. This inability is the logical consequence of the assumed large number of buyers and sellers, each of whom is small relative to the size of the market.

of manhours required to produce an airframe declined as more airframes were built.[6] The basic learning curve can be represented by

$$h_N = h_0 N^{\alpha} \quad , \tag{1}$$

with $\alpha < 0$ and $h_0 > 0$.

In equation 1, h_N can be interpreted in two ways. If equation 1 represents a unit learning curve, then h_N represents the manhours required to produce the Nth airframe, and the total manhours required to produce all N airframes H_N are given by

$$H_N = \sum_{n=1}^{N} h_n = \sum_{n=1}^{N} h_0 n^{\alpha} \quad . \tag{2}$$

Alternatively, if equation 1 represents a cumulative average learning curve, then h_N represents the average number of manhours required to produce each of the N airframes. Hence, the total manhours required to produce all N airframes are given by $H_N = Nh_N$. In either case, the learning curve is based on observing the direct labor requirements for production.

Whereas the learning curve provides the basic conceptual foundation for the models of pricing behavior in defense procurement, the accounting structure furnishes the framework within which the models are applied, and an examination of the accounting approach to system costs provides important insights into the acquisition process.[7]

The first step in estimating the cost of a weapon system is to translate the direct labor usage into direct labor costs, LC, by applying a wage rate to the observed manhour requirement. The next step is to add in the direct material costs, MC, resulting in the total direct cost, $DC(= LC + MC)$. Given the direct costs of producing the system, the indirect costs, IC, are computed by applying cost factors to the direct costs (i.e., $IC = \delta_L LC + \delta_M MC$, where δ_L and δ_M are the indirect cost factors associated with labor and materials, respectively, including general and administrative (G&A) costs). Total cost, TC, is the sum of the direct and indirect costs. The price, P, is determined by adding a fee, Π, to the total costs.[8] The basic accounting scheme can be summarized as:

$$LC = WH \tag{3}$$

[6] See [14] and [15] for detailed discussion of the learning curve.

[7] The accounting format outlined in the text is meant only to convey the basic approach and not the actual level of accounting detail available.

[8] The fee may take the form of a lump sum or may be computed as a fraction of total cost, π, such that $\Pi = \pi TC$ and $P = (1 + \pi)TC$.

$$
\begin{aligned}
DC &= LC + MC && (4)\\
IC &= \delta_L LC + \delta_M MC && (5)\\
TC &= DC + IC && (6)\\
\Pi &= \pi TC && (7)\\
P &= TC + \Pi = (1+\pi)TC \ , && (8)
\end{aligned}
$$

where W is the hourly wage, H is total labor input in manhours, and the remaining variables are as defined above.

The estimation process makes use of both the concept of learning and the basic accounting structure outlined in equations 3 through 8. By redefining the terms in equations 3 through 8, the costs and price can be stated on a per-unit or cumulative-average basis, depending on the chosen form of the labor learning curve.[9] A consequence of the accounting structure—the buildup from direct labor and material inputs to price by using multiplicative factors, δ_L, δ_M, and π—is the use of the Price Improvement Curve (PIC). The equation of the PIC is given by

$$P = P_1 Q^{\alpha} \ , \tag{9}$$

where

Q = a measure of the cumulative output

P_1 = the price of the first unit

$\alpha(< 0)$ = the price improvement parameter[10]

P = the price associated with the Qth unit.

As with the learning curve, the price in equation 9 can be interpreted as either a unit or the cumulative average price.[11]

Whichever interpretation is chosen, the PIC in equation 9 is one of two models directly relating the price of a system to the cumulative quantity. The second model is a version of

[9] If increased experience with the production process results in lower scrappage rates, materials costs, MC, will also display a "learning curve." This relationship may also be stated in either a unit or cumulative average form.

[10] Discussions of pricing behavior in this context typically focus on the value of the price improvement rate, which is computed as 2^{α}, rather than the price improvement parameter. For example, if $\alpha = -0.2$, then the price improvement rate is said to be 87 percent.

[11] Although the theoretical interpretations are clear, interpreting equation 9 as a unit price curve causes statistical problems in the typical application.

equation 9 that takes into account the effects of differing production rates on the price.[12] This rate-adjusted price-improvement curve, RAPIC, is given by

$$P_Q = P_1 Q^{\alpha} R^{\beta} \quad , \tag{10}$$

where

Q = the measure of cumulative output

R = the production rate, measured in units per period

P_1 = the price of the first unit if produced at a rate of one per period

$\alpha(< 0)$ = the price improvement parameter

$\beta(< 0)$ = the rate parameter

P_Q = the price of the Qth unit produced at rate R per period.

Equation 10 is less flexible to interpretation than equation 9. The use of the rate variable, R, which represents a flow of product per period of time, requires that equation 10 be interpreted as a unit price equation rather than a cumulative average price equation. Although interpreting equation 10 as a unit price equation does not present any theoretical problems, it does create empirical problems that are discussed in both [1] and [6].[13]

The importance of the PIC and RAPIC forms is apparent in the reliance of [4 through 10, 20 through 22, 27 and 28] on these forms as their basic models in evaluating the effects of competition on the prices of specific programs. The importance of the PIC and RAPIC equations in analysis is enhanced by the limited availability of data. The detailed direct cost data necessary to estimate the learning curve is considered procurement sensitive and is, in general, not available to nongovernment organizations engaged in the analysis of competition. In addition, the analyses in the reports cited above were retrospective. The major concern was whether competition had affected prices the government paid for specific weapon systems. In particular, did competition cause a reduction in the price paid by the government for a weapon system?

Thus, the models in this segment of the literature appear to have been used for three reasons. First, the combination of the accounting structure and the learning curve model provided for the logical development of the PIC or RAPIC models. Second, the study

[12] See [24], [25], and [26] for three views on the relationship between the production rate and the price.

[13] The discussion in [6] addresses the statistical problems associated with the RAPIC. However, their proposed solution also has substantial statistical problems.

organizations were typically limited to price-level data and did not have access to the detailed cost-level data necessary for estimating the labor and materials learning curves. Third, in order to assess the price effects and possible savings from competition, the studies were concerned with the effects of competition on the procurement prices for weapon system programs that had ended or were substantially complete.

The typical estimation and evaluation task within the defense procurement establishment differs from that of the literature. Although the models used are the same, the defense procurement establishment is usually faced with two problems: forecasting the prices of weapon systems not yet in production and determining whether contractor proposals for the production of systems are fair and reasonable. These problems are solved by using models that depend on the available information but are based on the learning curve and the accounting structure.

In the preproduction phase, forecasting starts with cost estimating relationships, CERs. A CER typically relates the number of manhours required to produce a particular unit to the technical characteristics of the system. In airframes, for example, the technical characteristics might include its weight, velocity, altitude, and other performance-related factors. The CERs are typically derived using detailed information from cross-sectional observations of similar systems.

An estimate of the number of direct labor hours required to produce the *nth* unit can be derived based on the estimated CER and the characteristics of the system under consideration. For the following discussion, assume that the CER provides estimates for the 100th unit. This CER estimate corresponds to h_{100} from the learning curve. A corresponding MC_{100} estimate can also be developed for the direct materials cost.

Given h_{100}, MC_{100}, the learning rates for the direct labor and materials, and a wage rate, an estimated price profile can be built based on the accounting structure that covers the procurement portion of the system life cycle.[14] These estimated prices play a dual role in the acquisition process. First, in conjunction with other information on the life-cycle costs of a system, they are one set of inputs to the budgeting process. Second, these estimated prices are part of the information available to the contracting officers for use in evaluating proposals and in the final negotiations leading to a government commitment to purchase a particular system.

In the production phase of a weapon system acquisition, the government's position will often be developed from PIC or RAPIC models. In many cases evaluation of contractor proposals and subsequent negotiations often will include, and may center on, the appropriate rate of price improvement. In turn, the appropriate rate of price improvement heavily depends on how the proposed price and implied rate of price improvement compare to the rates previously experienced on the specific program and/or on similar programs.

[14] Note that estimating relationships also exist for the other phases of the life cycle of a weapon system.

Two major conclusions can be drawn from this discussion of the institutional framework of the procurement evaluation process. First, the expectation that prices will fall with cumulative output is a basic premise of the government's model of procurement. Second, in evaluating an ongoing program, the government's position during negotiations will often depend on previous contract prices. These characteristics of procurement evaluation will be important in the development of an empirical model (the last section of this paper).

BEHAVIORAL ASSUMPTIONS

Formal models of economic phenomena typically start with the assumption that an agent wishes to attain a goal. The existing institutions and technology limit the actions the agent can take in pursuing the goal. The agent's behavior is then described in terms of a set of decision rules conditioned on institutional and technical constraints.

This section begins with basic behavioral assumptions about the objectives of the participants in the weapon system acquisition process, followed by a general discussion of the institutional characteristics of the process with an emphasis on the potential effects on the decision rules that the government will follow.

The motivation and consequent behavior of the employees representing the firms and the government in weapons acquisition are complex questions beyond the scope of this paper. This paper assumes that employees will attempt to meet objectives set by their employers. These objectives are given by two maintained hypotheses:

- The firm's objective is to maximize the present value of cash flows to the firm's stockholders.[15]
- The government's objective, in order of priority, is to obtain a workable weapon system, on schedule, and at a reasonable cost.[16]

The assumption that firms seek to maximize cash flow to the stockholders is a standard economic assumption. The assumed objective of the government is the more crucial assumption in the discussion that follows. A key feature of this assumption is the ordering of the objectives by priority.

The importance of this assumption can be seen in the way priorities influence source selection. One of the outcomes of the weapon system design and development process is

[15] Cash flow to the firm's stockholders includes capital gains, spinoffs to stockholders, payments in liquidation of bankruptcy, repurchase of shares, and any other payments to the stockholders.

[16] The discussion of the government's objectives and the factors influencing the price determination process are based primarily on observations of the Navy's approach to system acquisition and may be less relevant to the operations of other components of DOD.

the selection, for the production phase, of the "best" contractor, where "best" is defined using a set of weights applied to the technical and cost sections of the contractor's proposal. If the source selection process has chosen the best then, by definition, no other contractor is as good. Consequently, the emphasis on system performance leaves little leeway for the program manager to seek out an alternative (inferior) contractor.

Once the best contractor has been selected, the next task is to get the system into production and out to the operators. Good management is reflected in on-time deliveries. Delays in deliveries for major systems mean the operator will be without an important capability. Delays in deliveries for minor systems or subsystems may result in the delay of a major sytem or platform. Bringing on a new contractor may cause serious delays because the new person must essentially start at the beginning. The expectation of delayed delivery associated with a new contractor is a distinct disincentive to seeking new sources. In addition, changes in an established program are reflected in changes, usually increases, in current budget requirements.

The relatively low priority historically assigned to price/cost, especially during the initial stages of system development, and the potential performance, delivery, and budget problems associated with switching contractors on an established program offer little incentive for a program manager to seek out alternative production sources to save money.[17] This is particularly true when the incumbent contractor is demonstrating satisfactory progress in the areas of system performance and delivery. In addition, the acquisition community perceives that instituting a competitive program causes increases in current management and personnel costs in return for cloudy future benefits. Increases in management and personnel costs cause increases in the current budget requirement and in the level of activity required to justify the increased budget.

The initial selection of the best contractor, the consequent delivery and performance problems associated with switching contractors, and the clear budgetary effects of changing an ongoing acquisition program limit sharply the incentives that a program manager has to find alternative approaches to acquisition. In particular, during the time period considered for this study, so long as contractors provided workable systems, on schedule, at fair and reasonable prices there was no reason to seek alternative methods of acquisition, competitive or otherwise.

The normal method of acquisition relevant for this study can be described as a sole-source bargaining process in which the firm's basic problem is to estimate and propose the price that falls at the upper bound of the government's estimate of fair and reasonable. (As noted above, the government's estimate of fair and reasonable will be developed from learning curves and price improvement curves using past experience.) The lower bound of the price process is provided by the opportunity cost to the firm of committing its

[17] An additional consideration in the process is that the tradition of granting the production contracts on a sole-source basis to the system developer encourages the "buy-in." By proposing low prices in the early stages of a program the developer can essentially stake a claim to the particular system.

resources to a government program. Determining a specific price depends on myriad details of bargaining.

Several factors suggest that the outcome in most instances may be closer to the upper bound than to the lower. First, there is the low relative priority afforded to system price. Second, the techniques used to estimate program prices/costs are typically based on historical data provided by the contractors. As those responsible for estimating prices/costs lack the time and resources to validate either the data or the models, the acquisition system runs the risk of enshrining the mistakes (high prices) of the past.[18] Finally, the government enters this process as a supplicant. In the sole-source case, by the time of the production contract, the government has eliminated all but one producer from eligibility, thus effectively foreclosing all options for using alternative sources. On the other hand, the producers involved in the process are typically diversified and have alternative uses for the resources the government is seeking. The consequence of these factors is that the government appears to have a relatively weak bargaining position in most sole-source cases.

The existence of uncertainty and risk is ignored in the explicit statement of objectives. Both firm behavior and government behavior are influenced by decisions made in an uncertain environment. The behavioral hypotheses must recognize that the firm and the government are convenient fictional entities, and that decisions are made by individuals whose attitudes toward corporate or government risk-taking will be driven by their organization's attitudes toward risk. Consequently, the hypotheses also include consideration of various types of risk that may be associated with the development or production of weapon systems.

A MODEL

The model evolved by identifying variables that are expected to influence the price formation process and hypothesizing the direction of the expected influence. The variables expected to influence the outcome of the process fall into three main categories: technical, firm specific, and programmatic. The technical variables, which mainly describe system characteristics, are included because of their expected effect on the direct costs of producing the system. However, to the extent that the measurable characteristics reflect the complexity of the system they also provide a measure of the technical risk. The firm-specific factors include variables that reflect current and future business conditions for the firm. These variables address both the direct cost of engaging in a program and the opportunity cost. The programmatic variables are related to the specific program and/or to the government's evaluation process. This section will present the arguments leading to the basic functional form to be used in evaluating the procurement process.

[18]See [2] for a fuller discussion of this problem.

Economic models of the price-formation process generally provide qualitative hypotheses on the effects of various factors, but little guidance on the particular functional form these effects will take. In market-oriented models built around the concepts of perfect competition, pure monopoly, or regulation this lack of guidance on particular form is partially offset by the well-defined results of the model, which limit the applicable functional forms.

However, economic models of the defense acquisition process must recognize that weapons acquisition has been essentially a bilateral monopoly. As noted above, the economic theory of bilateral monopoly is indeterminate and provides, at best, only a range of possible outcomes. These results, such as they are, are based on standard assumptions about the objectives of the participants and the institutional and technical environment in which decisions are made.

Although the basic economic model applicable to defense acquisition is indeterminate, consideration of the institutional structure surrounding the procurement of a weapon system can provide guidelines about the functional form appropriate to an empirical model of the pricing process. Part of the indeterminate nature of the bilateral monopoly model arises from the generic nature of the institutional structure imposed. The indeterminancy can be reduced by incorporating specific features of the institutional structure.[19]

The PIC/RAPIC model discussed above provides the basic functional form for an empirical model of the price-formation process. The expectation of falling cost and price as cumulative output increases is firmly embedded in the estimation/evaluation process. This is evidenced in the techniques used to estimate intitial program costs and, more importantly for this discussion, in the use of the PIC or RAPIC model in negotiating ongoing programs. Given the government's expectations of pricing behavior, a firm may reduce both the direct and indirect costs of doing business with the government by proposing a set of prices whose general behavior fits the expected pattern. In particular, if the current proposal reflects sufficient "learning," the firm may be able to reach agreement with the government more quickly, producing reduced direct negotiation cost. In addition, a firm whose prices follow the expected pattern is less likely to attract the kind of attention that leads to special investigations and audits.

Given the functional form based on the PIC or RAPIC, the non-RAPIC factors are incorporated into the model by recognizing that the available observations are drawn from the realized contract prices. Although the basic form is a given, the intitial price and

[19]In the economic literature the Averch-Johnson (A-J) hypothesis, that firms subject to rate-of-return regulation tend to overcapitalize, is an example of a result due to recognition of the institutional structure. Even though there are many alternative hypotheses about the goals of the regulators, the A-J hypothesis is based on the recognition that the method of implementation of the regulatory decision is a common institutional feature of regulated markets. It is the way in which the decisions of the regulatory bodies are implemented, rather than the objectives of the regulators, that influences the decisions on the amount of capital to use.

subsequent prices are the results of bargaining in which the bargaining positions and outcomes depend on variables drawn from the catagories outlined above. Consider, for example, how the extent of automation in the production process could influence the negotiations and the conseqent prices. Given a relatively automated production line, the government could take the position that the intitial price should be lower than otherwise, as automation reduces the direct labor content.[20] The firm could accept this and counter with the argument that less labor leads to less learning and prices will not fall as rapidly as they otherwise would. These arguments would produce a price profile over time that started lower and remained flatter than would otherwise be the case.

The functional form that follows from the preceding arguments is a variable-coefficients model. For the weapon system pricing problem, this model has a general representation given by

$$P_t = P_1(\mathcal{F}, \mathcal{T}, \mathcal{P}) Q^{\alpha(\mathcal{F}, \mathcal{T}, \mathcal{P})} R^{\beta(\mathcal{F}, \mathcal{T}, \mathcal{P})} \quad , \tag{11}$$

where

$\mathcal{F}$ = a vector of firm-specific characteristics expected to influence the firm's pricing decisions and bargaining position

$\mathcal{T}$ = a vector of technical characteristics of the system which are expected to influence cost

$\mathcal{P}$ = a vector of program specific characteristics.

A simple model of this type is the shift and rotation model of the effects of competition whose variable coefficients form can be expressed as[21]

$$P_t = P_1(C) Q_t^{\alpha(C)} R_t^{\beta} \quad . \tag{12}$$

The particular form of equation 12 emphasizes that both the first unit price, $P_1(C)$, and the learning rate, $\alpha(C)$, are expected to depend on the presence of competition, C. The existence of competition is expected to cause both P_1 and α to decrease.

[20]This would be particularly true when the production equipment is paid for directly by the government.

[21]The presentations of the shift and rotation models are never explicitly expressed in this form.

When the competition variable, C, takes the value 1 in the presence of competition, and 0 otherwise, the functions, $P_1(C)$ and $\alpha(C)$ can be specified, for the shift and rotation hypothesis, as

$$\begin{aligned} P_1(C) &= P_0 \exp(\rho C) && (13) \\ \alpha(C) &= \alpha_0 + \alpha_1 C && (14) \\ \rho &< 0 \\ \alpha_0, \alpha_1 &< 0 \ . \end{aligned}$$

The values, P_0 and α_0, reflect the behavior of prices in the absence of competition, with ρ and α_1 representing the changes in the behavior of prices under competition. This particular formulation of the effects of competition on the behavior of prices in defense procurement is the simplest form of a variable-coefficients model.

The next step in obtaining an estimating equation is to note that in evaluating contractor proposals the functional form given by equation 10 is rarely, if ever, estimated directly. Instead, a logarithmic transformation is applied:

$$\ln P = \ln P_1 + \alpha \ln Q + \beta \ln R \ . \tag{15}$$

Given the contract history for a program, $\ln P$, $\ln Q$, and $\ln R$ are easily computed; estimates of $\ln P_1$, α, and β can be obtained using any of many available statistical packages.[22]

In keeping with the logic used to develop the theoretical form represented by equation 11, the empirical form should also reflect the estimation techniques used by the government to evaluate the proposals. In this case the appropriate form is log-linear, given by

$$\ln P = \ln P_1(\mathcal{F}, \mathcal{T}, \mathcal{P}) + \alpha(\mathcal{F}, \mathcal{T}, \mathcal{P}) \ln Q + \beta(\mathcal{F}, \mathcal{T}, \mathcal{P}) \ln R \ . \tag{16}$$

The estimating equation for the simple shift and rotation model, derived from the logarithmic transformation, can be expressed as

$$\ln P = \ln P_0 + \rho C + \alpha_0 \ln Q + \alpha_1 C \ln Q + \beta \ln R \ . \tag{17}$$

The major advantage of the log-linear form presented in equation 17 is that it is linear in the parameters—$\ln P_0$, ρ, α_0, α_1, and β. The linearity means the parameters are easily

[22] A number of statistical packages are available. They contain techniques for directly estimating the nonlinear form given by equation 10. However, the statistical properties of the estimates are not well defined for the range of sample sizes typically found in the analysis of specific weapon systems.

estimated. The major disadvantage associated with this form is that there are typically fewer than ten observations available on a specific program, so the resulting estimates cannot be interpreted with a great degree of confidence in their applicability. The inclusion of a broader range of factors, the technical and firm-specific information, allows for pooling observations from different systems and increases the number of observations. The result of this should be a greater degree of confidence in the estimates of the various effects.

The final step in obtaining the estimating equation is to specify the particular forms taken by functions $P_1(\mathcal{F}, \mathcal{T}, \mathcal{P})$, $\alpha(\mathcal{F}, \mathcal{T}, \mathcal{P})$, and $\beta(\mathcal{F}, \mathcal{T}, \mathcal{P})$. This step depends on the specific weapon systems to be considered and will be considered after the discussion of data used in this study.

THE DATA

The data used in this study consist of observations on specific production contracts for a set of tactical missiles. The contracts are identified by fiscal year, the system designator, and the firm receiving the contract. The missiles, the associated contractors, and the number of contracts are given in table 1. Ninety-nine observations (contracts) span the years 1965 through 1985. Each contract is specified as to contract type, acquisition method, contract quantity, price, and the item being purchased. In most cases the item being purchased is the guidance and control section of a missile. However, for some contracts only all-up-round[23] information was available. These additional parts are typically supplied by a subcontractor, with the prime contractor responsible for the guidance and control section and the final missile assembly.

TABLE 1

TACTICAL MISSILES AND CONTRACTORS

System	Designator	Contractor	Number of contracts
HARM	AGM-88A	Texas Instruments	5
Harpoon	RGM-84A	McDonnell	11
Hellfire	AGM-114A	Martin-Marietta	3
		Rockwell	3
Patriot	MIM-104	Raytheon	6
Sidewinder	AIM-9L/AIM-9M	Ford	4/4
		Raytheon	5/5
Sparrow	AIM-7F/AIM-7M	General Dynamics	6/4
		Raytheon	8/6
Standard	SM1/SM1 Block VI	General Dynamics	14/7
	SM2 Block I/ Block II	General Dynamics	4/4

The variables used in this study fall into three categories: technical, represented by $\mathcal{T}$; firm, represented by $\mathcal{F}$; and program, represented by $\mathcal{P}$. The variables in each category and their hypothesized influences on price formation are described below.

The technical variables are:

- DIG = 1 if onboard microprocessor; = 0 otherwise

[23] The all-up-round includes the rocket motor and warhead as well as the guidance and control section.

- RANGE = range of missile in nautical miles.

These factors vary by system rather than by time or contract. Another variable that varies by system, although classified as programmatic, is the development estimate of quantity, DEQ. These three variables are summarized in table 2.

TABLE 2

TACTICAL MISSILES—TECHNICAL AND SYSTEM CHARACTERISTICS

System	Designator	DIG	Range (n.mi.)	DEQ
HARM	AGM-88A	1	10	6,636
Harpoon	RGM-84A	1	60	2,870
Hellfire	AGM-114A	0	3.8	48,925
Patriot	MIM-104	1	37	6,250
Sidewinder	AIM-9L	0	1.9	13,449
	AIM-9M	0	1.9	11,080
Sparrow	AIM-7F	0	24	15,651
	AIM-7M	1	24	19,602
Standard	SM1	0	25	3,840
	SM1 Block VI	0	25	n/a
	SM2 Block I	1	25	6,195
	SM2 Block II	1	25	4,583

The technical variables are included to account for the complexity of the system and mission. More complex systems are expected to have higher costs that will be reflected in higher prices to the government. The DIG variable is one indicator of system complexity. Because systems including a microprocessor are generally expected to have more sophisticated signal processing capability, the existence of a microprocessor is expected to be associated with higher prices. Whereas the most obvious effect of range is on the fuel requirement, a second aspect of range is expected to influence the complexity and cost of the guidance and control system. Given the missile and fuel load, the missile's range will depend on the sophistication of the trajectory algorithm in the guidance system. The greater the range, the higher the expected price.

The development estimate of program quantity, DEQ, is the total number of units expected to be produced over the life of the program at, or just before, the first production contract award. It is a measure of the size of the program and consequently of the relative importance of the program to both the government and the firm. Although alternative

hypotheses about the effects of DEQ exist, the expectation is that DEQ is inversely related to the contract price.[24]

The firm variables are:

- RCF = total net cashflow to the firm in $millions deflated by the implicit gnp price deflator
- BLOGSALE = BACKLOG/SALES ratio
- DODPCNT = DOD contract awards as a fraction of sales.

The firm variables are intended to represent the position of the firm at the time of the contract award. The cash-flow variable, RCF, is a measure of the absolute position of the firm at the time of the contract award. In general, the contract price is expected to be positively related to RCF, as the higher the cash flow the better off the firm is and the less it needs a particular contract. However, RCF is also a measure of the size of the firm and may pick up economies of both scale and scope.[25]

The DODPCNT and BLOGSALE variables are measures of the future position of the firm. The BACKLOG variable measures the dollar value of the firm's unfilled orders and the DOD contract awards measures the dollar value of DOD awards to the firm during the current fiscal year. Because the SALES variable measures the total dollar volume of the firm's business in the current year, both DODPCNT and BLOGSALE can be interpreted as the number of years of business at current activity levels the firm has on order. The higher the level of future activity the less the firm needs any particular contract and the greater the potential cost to the firm of accepting a particular contract. Consequently, both variables are expected to be positively related to the contract price. These effects may be stronger in the early stages of a program before the firm has committed to a particular program, and at the end when the firm is winding down its commitment and looking for alternative ways to use its resources.

An alternative hypothesis exists for the DODPCNT variable. This variable indicates the relative importance of defense business to the firm.[26] The greater the importance of DOD business to the firm the lower the price they might charge, so as not to jeopardize

[24] There is a clear cause-and-effect question on this variable, as the DEQs tend to be higher on those programs for which the government expects to have low prices. However, to the extent that high DEQs are indicators of an important program, firms may view these programs as less risky and use relatively more specialized production techniques with lower costs and less flexibility.

[25] "Economies of scope" refers to benefits, usually taking the form of lower costs, that may accrue to a multiproduct firm and arise from diversification.

[26] All of these firms are important to DOD. They are all in the top 100 defense contractors and are major prime contractors in the production of missiles. Hughes is the only major missile firm excluded because the required firm data were not available.

their position within the defense industry. Which of the hypothesized effects dominates may depend on the diversity of the firm's defense business and on the importance of the particular program under consideration to the long-term plans of the firm (i.e., a firm with one large program making up a substantial portion of its business may have an incentive to keep its prices lower than it otherwise would).

Note that the firm (corporate) variables are measured at the firm level. If all decisions were made at the corporate level, it would be appropriate to use only corporate-level variables in making those decisions. But decisions are usually made at either the corporate or division levels, so variables from both levels should be used. For this study, however, both those sets of data were not uniformly available, so only firm-level data are used here to draw conclusions.

The programmatic variables associated with the current contract are:

- BUY = the number of units purchased under the current contract
- CUMQ = total number of units purchased through the end of the current contract
- WPN = WPN (Weapons Procurement Navy) deflator (1984=100)
- P = per unit price in $thousands = $ value of contract/BUY
- P_{FY84} = price in FY84$K = P/WPN
- DEQ = development estimate of program quantity (discussed above)
- PCTPROG = fraction of the program completed at the end of the current contract = CUMQ/DEQ
- SSFC = 1 if a sole source award in a program with a subsequent competition; = 0 otherwise
- COMP = 1 if competitive award; = 0 otherwise
- AURD = 1 if all-up-round is purchased; = 0 otherwise
- CAPIP = implied cumulative average price improvement parameter.

Of the variables listed above, P, P_{FY84}, BUY, and CUMQ are clearly defined. The remaining variables require some explanation.

WPN is a price deflator for Navy weapons. As such, it provides a measure of the trend of prices in acquiring weapons and serves as proxy for the general level of cost in systems production. In general, WPN and the contract price are expected to be positively related.

The PCTPROG variable measures the fraction of the program completed at the end of the current contract relative to the development estimate of the program. The hypothesis is that the further along the program is the less likely the government is to bring in a competitor and the higher the price that the incumbent firm may charge.

The SSFC and COMP variables are indicators of the acquisition method. If both SSFC and COMP are zero, then the contract was negotiated as a sole-source contract and is in a program that was never subject to competition in subsequent years. This means of classifying the acquisition method makes a sole-source program the baseline against which alternative acquisition methods are to be evaluated. This definition corresponds to the acquisition method used most frequently for major systems during most of the period under consideration.

If SSFC = 1, then the contract under consideration is a sole-source contract in a program that had competitive contract awards at some later date. Three hypotheses are relevant to the SSFC variable: the skimming, limit-pricing, and problem-program hypotheses.[27] The skimming hypothesis suggests that firms facing an upcoming competition may raise their prices in an attempt to take their profits before the introduction of another firm. The limit-pricing hypothesis states that the firm facing an upcoming competition may lower its price to convince the government that competition is not an economically viable acquisition strategy. The problem-program hypothesis runs in the other direction, stating that competition is introduced because of problems in the early stages of a program and that one indicator of a program in trouble is a high price.

Two comments are called for regarding these hypotheses. First, the skimming and problem-program hypotheses are observationally equivalent. Both the skimming and problem-program hypotheses imply the same effects on the price relative to a normal sole-source program. Unless there is qualitative information on the program, it will not be possible to identify the cause of a higher price.

In addition, identifying limit-pricing behavior is unlikely because successful limit pricing will result in no competition on a program and consequently will be recorded as a sole-source program. If it becomes clear that a limit-pricing strategy is unsuccessful (i.e., competition is inevitable), then the strategy will be dropped and subsequent prices are more likely to reflect skimming.

AURD is an indicator variable that identifies those contracts in which it is not possible to identify Guidance and Control section prices because the contract is for an all-up-round. AURD is expected to be positively related to price.

[27]The *skimming* hypothesis has been discussed in detail in both [4] and [1]. The limit-pricing hypothesis can be found in [4]. The problem program hypothesis has been discussed in [1] as it relates to the issue of selectivity bias in sample selection procedures.

CAPIP is a measure of the price improvement parameter between the current and last contract as applied to the cumulative average deflated price. CAPIP is computed from the following formula:

$$CAPIP_i = \ln(\overline{P}_i/\overline{P}_{i-1})/\ln(CUMQ_i/CUMQ_{i-1}) \quad ,$$

where $\overline{P}_i$ is the cumulative average price[28] in FY 1984 dollars and $CUMQ_i$ is the cumulative quantity through the end of the i-th contract. This variable provides a summary measure of the program history. As a measure of the most recently revealed aggregate price improvement parameter based on cumulative average prices, CAPIP summarizes the history of the price process. Because high values of CAPIP imply low rates of price improvement, CAPIP is expected to be positively related to the contract price.

The largest complete data set has 80 observations, which were used to obtain the results discussed below. Eight observations are lost from the 99 contracts because Ford Motor Company does not provide information on order backlog. Four observations on the Standard Missile I are not usable, as no information on GD is available from the pre-1970 period. Finally, seven observations are lost on the Standard Missile 1 Block VI because no development estimate of the program quantity was available.

The firm and program variables are summarized in table 3.

[28] $\overline{P}_i$, the cumulative average price, is calculated as total program expenditures (in FY84 dollars) through the end of the i-th contract divided by the cumulative output through the end of the i-th contract.

TABLE 3

SUMMARY OF VARIABLES

Variable	Observations	Mean	Standard deviation	Minimum	Maximum	Comments
Firm:						
RCF	95	596.7	801.4	-611.5	4,235.8	$M 1984
SALES	95	8,257.9	11,077.6	1,465.0	5,2774.0	$M
BLOGSALE	87	1.57	0.67	0.18	3.14	
DODBUS	95	2,920.7	2,147.7	338.0	8,857.0	$M
DODPCNT	95	0.55	0.29	0.01	1.30	
Program:						
P	99	273.8	323.4	13.3	1,260.0	$K
P_{FY84}	99	407.3	536.4	18.6	3,061.3	$K FY84
BUY	99	913	807	15	4,415	
CUMQ	99	2,938	2,708	15	11,034	
CAPIP	99	-0.19	0.18	-0.69	0.19	

AN EMPIRICAL MODEL

The empirical model used in this study is a variation of the rate-adjusted price-improvement curve, RAPIC, found in the literature and discussed in detail in [1]. The simple log-linear version of the RAPIC, introduced in 15, is reproduced by

$$\ln P = \ln P_1 + \alpha \ln CUMQ + \beta \ln BUY \quad , \tag{18}$$

where $\ln P_1$ is the log of the first unit price, α is the (constant) price improvement parameter, and β is the (constant) rate parameter. In this format the contract price depends only on the first unit price, the cumulative level of output, and annual quantity.

Based on the discussion above, the generalized version of the empirical model is reproduced as

$$\ln P = \ln P_1(\mathcal{T}, \mathcal{F}, \mathcal{P}) + \alpha(\mathcal{T}, \mathcal{F}, \mathcal{P}) \ln CUMQ + \beta(\mathcal{T}, \mathcal{F}, \mathcal{P}) \ln BUY \quad . \tag{19}$$

In the generalized model, the first unit price, the price improvement parameter, and the rate parameter are assumed to depend on the technical, firm, and program characteristics. The assumed relationships among the technical, firm, and program variables and the parameters are given by

$$\begin{aligned}
\ln P_1 &= \rho_0 + \rho_1 DIG + \rho_2 RANGE + \rho_3 SSFC + \rho_4 COMP + \rho_5 AURD \\
&\quad + \rho_6 DEQ + \rho_7 PCTPROG + \rho_8 CAPIP + \rho_9 WPN + \rho_{10} RCF \\
&\quad + \rho_{11} DODPCNT + \rho_{12} BLOGSALE + \rho_{13} COMP * PCTPROG \qquad (20) \\
\alpha &= \alpha_0 + \alpha_1 DIG + \alpha_2 RANGE + \alpha_3 SSFC + \alpha_4 COMP + \alpha_5 AURD \\
&\quad + \alpha_6 DEQ + \alpha_7 PCTPROG + \alpha_8 CAPIP + \alpha_9 WPN + \alpha_{10} RCF \\
&\quad + \alpha_{11} DODPCNT + \alpha_{12} BLOGSALE + \frac{\alpha_{13}}{2} \ln CUMQ \qquad (21) \\
\beta &= \beta_0 + \beta_1 DIG + \beta_2 RANGE + \beta_3 SSFC + \beta_4 COMP + \beta_5 AURD \\
&\quad + \beta_6 DEQ + \beta_7 PCTPROG + \beta_8 CAPIP + \beta_9 WPN + \beta_{10} RCF \\
&\quad + \beta_{11} DODPCNT + \beta_{12} BLOGSALE + \frac{\beta_{13}}{2} \ln BUY \quad . \qquad (22)
\end{aligned}$$

Substituting the expressions in equations 20 through 22 into equation 19 and adding an appropriate error term gives the basic estimating equation for the model.[29]

[29] The division of α_{13} and β_{13} by 2 in equations 21 and 22 is done for computational convenience in evaluating the effects of changes in the cumulative quantity and the annual buy.

In estimating the relationship defined by equations 19 through 22, two specifications were used:

- Specification $\mathcal{A}$—defined in equations 19 and 20 through 22
- Specification $\mathcal{L}$—In $\mathcal{L}$, the variables RANGE, DEQ, and WPN are replaced in equations 20 through 22 by $\ln RANGE$, $\ln DEQ$, and $\ln WPN$.

Two estimating equations are associated with each specification. The first has $\ln P$ as the dependent variable. The second uses $\ln P_{FY84}$ as the dependent variable.

One way to evaluate the effects of the variables in the model on the contract price is to examine the partial derivative of the price equation with respect to the variable of interest. However, this approach estimates the effects sensitive to the units of measure; for example, changing the measure from hundreds of units to thousands of units will result in a tenfold increase in the estimate of the partial derivative. This dependence on the units of measure also makes comparisons among different variables difficult.

One solution to the units-of-measure problem is to evaluate the effect of a variable on price in terms of elasticity, where the elasticity is the ratio of the percentage change in price to the percentage change in the variable under consideration. The elasticity of price with respect to some variable X, η_X, can be defined as

$$\eta_X = (\frac{\partial P}{\partial X})(\frac{X}{P}) \quad . \tag{23}$$

For the models considered here, the elasticity calculations are computed based on the definitions given in equations 24 and 25:

$$\eta_X = \frac{\partial \ln P}{\partial \ln X} \tag{24}$$

$$\eta_X = (\frac{\partial \ln P}{\partial X})X \quad . \tag{25}$$

For example, if the model is based on specification $\mathcal{A}$, the elasticity with respect to DEQ is

$$\eta_{DEQ} = \rho_6 DEQ + \alpha_6 \ln CUMQ * DEQ + \beta_6 \ln BUY * DEQ \quad . \tag{26}$$

For the model based on specification $\mathcal{L}$, the elasticity is computed from

$$\eta_{DEQ} = \rho_6 + \alpha_6 \ln CUMQ + \beta_6 \ln BUY \quad . \tag{27}$$

In equations 26 and 27, the elasticity is computed at a particular point defined by $\ln CUMQ$, $\ln BUY$, and, in the case of specification $\mathcal{A}$, DEQ.

The models defined above are linear in the parameters, and the application of least squares techniques will result in estimates of the variances and covariances of the parameters. Because the elasticity calculations are linear combinations of the parameters, it is possible to use the variance-covariance matrix of the parameters to estimate the variances of the computed elasticities.

PROCEDURE

This section discusses the procedure used to generate the results. Parameter estimates were obtained using ordinary least squares. As the annual buy is typically predetermined based on the procurement plans and exogenous requirements, the simultaneity problems associated with price-quantity models are not present.

Two approaches exist to estimating models with a large number of right-hand side variables. One method starts large and eliminates variables that fail to satisfy a criterion for retention. The other method starts small and then adds variables to the model keeping those that meet the conditions for retention.

The first approach was chosen for this study because of the exploratory nature of this research. It seemed more appropriate to start with the complete, or unrestricted, model implied by equations 20 through 20 and to use statistical tests to eliminate variables that have no influence on price. Also, there were no strong prior beliefs about which particular coefficients or groups of coefficients should be zero.

The implementation of the first approach was carried out as follows. Three parameters—ρ, α, and β—are associated with each of the nontraditional variables[30]. The hypothesis that the i-th variable has no effect on the price can be stated as a set of restrictions on the value of the parameters given by $\rho_i = \alpha_i = \beta_i = 0$. The results of the least-squares estimation with the restrictions imposed can be compared to the results of the least-squares estimation with no restrictions and a decision as to whether to reject or not reject the restriction.

Because the analysis at this stage is not concerned with the individual parameter estimates as much as it is with the existence of overall effects by the variables, the approach outlined above seems to offer less of a chance of excluding an influential variable, albeit with a concomitant greater chance of including insignificant variables. Finally, the problems associated with the including irrelevant explanatory variables are less serious than those associated with excluding relevant explanatory variables.

Given this basic approach, there are four basic models reported here:

- Model 1—the complete, unrestricted, model specified above, based on the 14 basic variables, so that when all interaction or secondary terms are included, 42 parameters are to be estimated.
- Model 2—assumes no digital effects of the price of a weapon system; with the digital variables excluded, there are 39 parameters.

[30]DIG, RANGE, SSFC, COMP, AURD, DEQ, PCTPROG, CAPIP, WPN, RCF, *PCTDOD*, and BLOGSALE are the nontraditional variables.

- Model 3—excludes the backlog/sales ratio variables, without which this model also has 39 parameters.
- Model 4—excludes both the digital and backlog/sales ratio variables; 36 parameters are estimated in this model.

Because each model is estimated for each specification, $\mathcal{L}$ and $\mathcal{A}$, and for each dependent variable, $\ln P$ and $\ln P_{FY84}$, a total of 16 equations are estimated. The results are labeled according to the model, specification, and dependent variable. For example, 1.$\mathcal{L}$.N refers to model 1 estimated with the variables measured according to $\mathcal{L}$ and with $\ln P$ as the dependent variable, whereas 3.$\mathcal{A}$.R refers to model three with the variables measured according to $\mathcal{A}$ and with $\ln P_{FY84}$ as the dependent variable.[31]

A final comment on the procedure concerns the error term. For the results presented below, the error term was assumed to be homoscedastic, nonautoregressive, and have no contemporaneous correlations. With the exception of the test for heteroscedasticity reported below, all of these assumptions were maintained hypotheses. These are strong assumptions that need to be relaxed and tested. However, a detailed examination of the structure of the variance of the pricing process was outside the scope of this effort and must be left to future research.

[31] The $\mathcal{L}$.N and $\mathcal{L}$.R models differ only in the coefficient on WPN (i.e., ρ_9). This is because $P_{FY84} = P/WPN$ and the logarithmic transform is equivalent to subtracting $\ln WPN$ from both sides of the $\ln P$ equation.

RESULTS

A number of issues need to be considered in reporting the results of the estimation procedure. The first is the overall suitability of the model. The analysis of variance tables for each of the regressions reveals that by the conventional measure of goodness of fit, the models fit well. The F statistics are all highly significant, and the R^2s are all around 0.99.[32]

The second issue when dealing with cross-sectional data concerns the existence of heteroscedastic errors. Both $\ln P$ and $\ln P_{FY84}$ were grouped according to hypothesized differences in the variance. Bartlett's test [3, p. 143] was then applied to the grouped data. In all cases the hypothesis of homoscedasticity could not be rejected.

Finally, a test of model 4 against model 1 fails to reject the restrictions of model 4. The F statistics for model 1 versus model 4 are 1.04 for both $\mathcal{L}$.N and $\mathcal{L}$.R, 0.88 for $\mathcal{A}$.N, and 1.12 for $\mathcal{A}$.R. The corresponding alpha levels are 0.41, 0.51, and 0.37.

Given the functional form chosen for this research, the effects of individual variables on the acquisition process can be evaluated in three dimensions: the overall effect, as measured by the elasticity; the price improvement effect, as measured by the coefficient on the product of the log of cumulative quantity and the variable (i.e., the α_is); and the annual buy effect, as measured by the coefficient on the product of the log of the annual buy and the variable (i.e., the β_is).

Because the elasticities are not constant, they must be evaluated at a particular point. The values of the variables at the evaluation point are given in table 4. The estimated elasticities for each of the variables for each of the regression equations are reported in table 5; the parameter estimates are reported in table 6.

The values presented in table 4 and used in evaluating of the elasticities are based on the mean values of the digital and nondigital systems used in this study. They represent of the distinguishing characteristics of the respective systems. Consequently, case 1 is representative of the conditions surrounding a more complex system. The key features of the more complex systems are a digital processor, longer range, and smaller quantities. Case 2 represents a less complex system (i.e., no digital processor), shorter range, and higher quantities. For the elasticities computed here, the two cases highlight the effects of quantities on determining contract price.

[32]The detailed regression results are reported in appendix A.

TABLE 4

VALUES FOR THE EVALUATION OF ELASTICITIES

	DIG	RANGE	PCNTPROG	CAPIP	WPN	RCF
Case 1	1	35	.2	-.17	.83	460
Case 2	0	15	.2	-.21	.63	351

	DODPCNT	BLOGSALE	CUMQ	BUY	DEQ
Case 1	.60	1.4	1,700	600	8,500
Case 2	.55	1.6	3,400	1,200	17,000

TABLE 5

ELASTICITY ESTIMATES

VARIABLE	CASE	Model											
		1.$\mathcal{L}$.N(R)	2.$\mathcal{L}$.N(R)	3.$\mathcal{L}$.N(R)	4.$\mathcal{L}$.N(R)	1.$\mathcal{A}$.N	1.$\mathcal{A}$.R	2.$\mathcal{A}$.N	2.$\mathcal{A}$.R	3.$\mathcal{A}$.N	3.$\mathcal{A}$.R	4.$\mathcal{A}$.N	4.$\mathcal{A}$.R
DIG	1	0.207		0.194		0.179	0.197			0.172	0.202		
	2	0.201		0.169		0.184	0.257$^+$			0.164	0.237$^+$		
BACKLOG/	1	0.149	0.114			0.147$^+$	0.145$^+$	0.141	0.123				
SALES	2	0.146	0.099			0.171	0.147	0.151	0.143				
RANGE	1	0.695$^+$	0.772$^+$	0.682$^+$	0.761$^+$	1.737$^+$	1.711$^+$	1.840$^+$	1.784$^+$	1.688$^+$	1.649$^+$	1.790$^+$	1.740$^+$
	2	0.638$^+$	0.693$^+$	0.631$^+$	0.683$^+$	0.833$^+$	0.814$^+$	0.879$^+$	0.873$^+$	0.811$^+$	0.794$^+$	0.856$^+$	0.850$^+$
AURD	1	0.229$^+$	0.112	0.122	0.033	0.117	0.192	0.010	0.074	0.045	0.124	-0.055	0.017
	2	0.035	-0.102	-0.084	-0.179	0.036	0.170	-0.136	-0.069	-0.058	0.078	-0.206	-0.137
PCNTPROG	1	0.095	0.071	0.098	0.075	0.057	0.086	0.049	0.096	0.031	0.067	0.024	0.072
	2	0.073	0.046	0.067	0.043	0.072	0.101	0.056	0.091	0.046	0.078	0.032	0.068
CAPIP	1	0.196$^+$	0.224$^+$	0.184$^+$	0.213$^+$	0.131$^+$	0.122$^+$	0.143$^+$	0.128$^+$	0.119$^+$	0.108$^+$	0.132$^+$	0.117$^+$
	2	0.209$^+$	0.245$^+$	0.201$^+$	0.238$^+$	0.054	0.037	0.068	0.051	0.045	0.027	0.059	0.042
RCF	1	-0.194$^+$	-0.174	-0.192$^+$	-0.172	-0.109	-0.113	-0.128	-0.180$^+$	-0.119	-0.130	-0.134	-0.185$^+$
	2	-0.030	-0.040	-0.056	-0.056	0.040	0.027	0.019	-0.008	0.005	-0.009	-0.014	-0.038
WPN	1	1.481$^+$	1.698$^+$	1.466$^+$	1.680$^+$	1.887$^+$	0.695$^+$	2.130$^+$	0.947$^+$	1.827$^+$	0.623$^+$	2.066$^+$	0.887$^+$
	2	1.496$^+$	1.680$^+$	1.488$^+$	1.649$^+$	1.404$^+$	0.478$^+$	1.582$^+$	0.730$^+$	1.374$^+$	0.453$^+$	1.533$^+$	0.687$^+$
CUMQ	1	-0.164	-0.195	-0.176	-0.205	-0.402$^+$	-0.458$^+$	-0.436$^+$	-0.517$^+$	-0.343$^+$	-0.408$^+$	-0.379$^+$	-0.461$^+$
	2	-0.200	-0.233	-0.220	-0.241	-0.365	-0.433$^+$	-0.337	-0.398$^+$	-0.304	-0.384$^+$	-0.280	-0.339$^+$
BUY	1	-0.165	-0.099	-0.136	-0.090	-0.118	-0.091	-0.055	-0.001	-0.103	-0.079	-0.048	0.007
	2	0.070	0.189	0.146	0.214	-0.335	-0.359$^+$	-0.311	-0.339$^+$	-0.286	-0.315	-0.280	-0.307$^+$
DODPCNT	1	-0.312$^+$	-0.331$^+$	-0.214$^+$	-0.255$^+$	-0.301$^+$	-0.314$^+$	-0.341$^+$	-0.360$^+$	-0.161$^+$	-0.188$^+$	-0.211$^+$	-0.244$^+$
	2	-0.619$^+$	-0.630$^+$	-0.513$^+$	-0.546$^+$	-0.609$^+$	-0.591$^+$	-0.656$^+$	-0.684$^+$	-0.441$^+$	-0.450$^+$	-0.497$^+$	-0.537$^+$
DEQ	1	-0.719$^+$	-0.732$^+$	-0.605$^+$	-0.639$^+$	-0.319$^+$	-0.324$^+$	-0.313$^+$	-0.315$^+$	-0.275$^+$	-0.273$^+$	-0.263$^+$	-0.275$^+$
	2	-0.400$^+$	-0.399$^+$	-0.300$^+$	-0.323$^+$	-0.329$^+$	-0.344$^+$	-0.282$^+$	-0.280$^+$	-0.261$^+$	-0.269$^+$	-0.213	-0.221
SSFC	1	0.851$^+$	0.816$^+$	0.676$^+$	0.682$^+$	0.642$^+$	0.701$^+$	0.589$^+$	0.592$^+$	0.510$^+$	0.558$^+$	0.456$^+$	0.479$^+$
	2	0.263	0.186	0.104	0.082	0.263	0.326	0.166	0.184	0.134	0.199	0.051	0.078
COMP	1	0.657$^+$	0.630$^+$	0.478$^+$	0.485$^+$	0.645$^+$	0.661$^+$	0.592$^+$	0.562$^+$	0.519$^+$	0.521$^+$	0.457$^+$	0.448$^+$
	2	0.370	0.297	0.170	0.153	0.528$^+$	0.572$^+$	0.434$^+$	0.440$^+$	0.362	0.405$^+$	0.275	0.296

$^+$ indicates $\alpha \leq 0.10$

TABLE 6

PARAMETER ESTIMATES

	Model											
VARIABLE	1.$\mathcal{L}$.N(R)	2.$\mathcal{L}$.N(R)	3.$\mathcal{L}$.N(R)	4.$\mathcal{L}$.N(R)	1.$\mathcal{A}$.N	1.$\mathcal{A}$.R	2.$\mathcal{A}$.N	2.$\mathcal{A}$.R	3.$\mathcal{A}$.N	3.$\mathcal{A}$.R	4.$\mathcal{A}$.N	4.$\mathcal{A}$.R
DIG	0.369		0.499		0.106	-0.491			0.226	-0.246		
QDIG	-0.0974		-0.0753		0.0251	0.131			0.0207	0.122		
BUYDIG	0.0880		0.0399		-0.-178	-0.0447			-0.0324	-0.0719		
BLOGSALE	0.266	0.298			0.0664	0.215	0.152	0.0625				
QBLS	-0.0747	-0.0677			-0.0432	-0.0563	-0.0510	-0.0448				
BUYBLS	0.0618	0.0449			0.0563	0.0479	0.0514	0.0560				
RANGE	1.297$^+$	1.627$^+$	1.218$^+$	1.588$^+$	-0.00174	0.00481	0.000328	-0.0105	-0.00438	-0.00277	-0.00152	-0.0108
QRANG	-0.0786	-0.125$^+$	-0.0603	-0.104$^+$	-0.00291	-0.00554	-0.00367	-0.00515	-0.00110	-0.00351	-0.00168	-0.00344
BUYRANG	-0.00270	0.0117	-0.0136	-0.00851	0.0114$^+$	0.0133$^+$	0.0124$^+$	0.0156$^+$	0.00950$^+$	0.0119$^+$	0.0102$^+$	0.0135
AURD	2.341$^+$	2.336$^+$	2.266$^+$	2.174$^+$	1.243	0.715	1.657$^+$	1.622$^+$	1.340	0.827	1.595$^+$	1.623$^+$
QAURD	-0.311$^+$	-0.236$^+$	-0.230$^+$	-0.174	-0.362$^+$	-0.317$^+$	-0.286$^+$	-0.214	-0.329$^+$	-0.274$^+$	-0.250$^+$	-0.181
BUYAURD	0.0317	-0.0734	-0.0674	-0.132	0.245	0.287	0.0750	0.00671	0.180	0.209	0.0328	-0.0402
PCNTPROG	1.873	1.876	2.388	2.290	-0.296	-0.182	0.00416	0.932	-0.430	-0.0709	-0.135	0.776
QPCTPROG	-0.368$^+$	-0.338$^+$	-0.423$^+$	-0.394$^+$	-0.0935	-0.0820	-0.119	-0.207	-0.0764	-0.0894	-0.104	-0.192
BYPCTPRG	0.209	0.155$^+$	0.195	0.159$^+$	0.200$^+$	0.191$^+$	0.176$^+$	0.170$^+$	0.180$^+$	0.168$^+$	0.161$^+$	0.159$^+$
CAPIP	2.715$^+$	2.885$^+$	2.227$^+$	2.416$^+$	5.417$^+$	5.846$^+$	5.637$^+$	5.550$^+$	5.015$^+$	5.262$^+$	5.157$^+$	5.187$^+$
QCAPIP	-0.118	-0.171	0.00855	-0.0652	0.0471	-0.118	0.0164	-0.105	0.180	0.0285	0.151	0.00433
BUYCAPIP	-0.107	-0.0461	-0.189	-0.106	-0.782$^+$	-0.664$^+$	-0.768$^+$	-0.628$^+$	-0.883$^+$	-0.757$^+$	-0.860$^+$	-0.708$^+$
RCF	-0.00333$^+$	-0.00263$^+$	-0.00259$^+$	-0.002115$^+$	-0.00364$^+$	-0.00339$^+$	-0.00341$^+$	-0.00384$^+$	-0.00289$^+$	-0.00279$^+$	-0.00263$^+$	-0.00314$^+$
QRCF	-0.000183	-0.000199	-0.000190	-0.000195	0.000135	0.000150	0.0000621	0.0000445	0.000114	0.000117	0.0000355	0.0000260
BUYRCF	0.000666$^+$	0.000582$^+$	0.000561$^+$	0.000505	0.000374	0.000317	0.000417	0.000487	0.000279	0.000255	0.000325	0.000397

$^+$ indicates $\alpha \leq 0.10$

TABLE 6 (Continued)

	Model											
VARIABLE	1.$\mathcal{L}$.N(R)	2.$\mathcal{L}$.N(R)	3.$\mathcal{L}$.N(R)	4.$\mathcal{L}$.N(R)	1.$\mathcal{A}$.N	1.$\mathcal{A}$.R	2.$\mathcal{A}$.N	2.$\mathcal{A}$.R	3.$\mathcal{A}$.N	3.$\mathcal{A}$.R	4.$\mathcal{A}$.N	4.$\mathcal{A}$.R
WPN	0.934	1.598$^+$	0.870	1.708$^+$	3.060$^+$	2.201	3.465$^+$	1.440$^+$	2.686$^+$	1.598	3.327$^+$	1.297
QWPN	0.394$^+$	0.257	0.380$^+$	0.252	-0.524	-0.669$^+$	-0.553$^+$	-0.537$^+$	-0.454	-0.584$^+$	-0.495$^+$	-0.489$^+$
BUYWPN	-0.373	-0.284	-0.349	-0.297	0.486	0.564	0.502$^+$	0.578$^+$	0.452	0.546	0.444	0.533$^+$
LCUMQ	1.640	1.467	1.356	1.253	1.473$^+$	1.614$^+$	1.343$^+$	1.436$^+$	1.084$^+$	1.201$^+$	0.934	1.062$^+$
Q2	-0.190	-0.154	-0.140	-0.109	-0.198$^+$	-0.214$^+$	-0.171$^+$	-0.185$^+$	-0.154$^+$	-0.170$^+$	-0.126	-0.142$^+$
LBUY	-3.557$^+$	-3.409$^+$	-3.338$^+$	-3.237$^+$	0.153	0.0862	0.443	0.287	0.306	0.190	0.555	0.438
BUY2	-0.0845	-0.125	-0.0987	-0.136	-0.163	-0.161	-0.209$^+$	-0.210$^+$	-0.162	-0.156	-0.201$^+$	-0.209$^+$
DODPCNT	5.116$^+$	4.916$^+$	5.074$^+$	4.880$^+$	4.962$^+$	4.446$^+$	5.036$^+$	5.218$^+$	4.599$^+$	4.323$^+$	4.638$^+$	4.802$^+$
QPCNT	-0.0370	0.0116	-0.104	-0.0492	0.123	0.111	0.159	0.114	0.0569	0.0312	0.0911	0.0489
BUYPCNT	-0.838$^+$	-0.868$^+$	-0.728$^+$	-0.772$^+$	-0.997$^+$	-0.906$^+$	-1.061$^+$	-1.042$^+$	-0.827$^+$	-0.761$^+$	-0.886$^+$	-0.871$^+$
DEQ	-3.697$^+$	-3.833$^+$	-3.437$^+$	-3.555$^+$	-0.000212$^+$	-0.000213$^+$	-0.000230$^+$	-0.000233$^+$	-0.000198$^+$	-0.000193$^+$	-0.000209$^+$	-0.000219$^+$
QDEQ	0.0358	0.0211	0.0116	-0.00471	0.00000723	0.00000936	0.00000603	0.00000521	0.00000877	0.0000105	0.00000781	0.00000676
BUYDEQ	0.424$^+$	0.460$^+$	0.429$^+$	0.461$^+$	0.0000189	0.0000164	0.0000232$^+$	0.0000246$^+$	0.0000157	0.0000129	0.0000187	0.0000212$^+$
SSFC	6.600$^+$	6.944$^+$	6.179$^+$	6.449$^+$	4.453$^+$	4.451$^+$	4.827$^+$	4.685$^+$	4.266$^+$	4.106$^+$	4.481$^+$	4.471
QSSFC	-0.314	-0.301	-0.218	-0.217	-0.308	-0.279	-0.328	-0.314	-0.275	-0.234	-0.280	-0.280
BUYSSFC	-0.534$^+$	-0.608$^+$	-0.606$^+$	-0.649$^+$	-0.237	-0.262	-0.282	-0.275	-0.268	-0.283	-0.304	-0.298
COMP	3.732$^+$	4.172$^+$	3.720$^+$	3.991$^+$	1.993$^+$	1.740	2.382$^+$	1.998$^+$	2.250$^+$	1.850$^+$	2.481$^+$	2.179$^+$
QCOMP	-0.372	-0.433$^+$	-0.361	-0.420$^+$	-0.184	-0.162	-0.265	-0.243	-0.201	-0.173	-0.281	-0.262
BUYCOMP	-0.0414	-0.0459	-0.0832	-0.0577	0.0156	0.0340	0.0377	0.0684	-0.0253	0.00583	0.0182	0.0426
COMPCTPR	-0.220	-0.126	-0.138	-0.0594	-0.413	-0.455	-0.306	-0.316	-0.375	-0.399	-0.254	-0.275

$^+$ indicates $\alpha \leq 0.10$

DIGITAL PROCESSOR

Perhaps the most surprising factor associated with a digital processor is that, within the sample used for this research, the presence of the microprocessor is relatively unimportant. In all cases the overall effect is positive with estimates ranging from 0.164 to 0.257. However, the estimate is not substantially larger than its standard error.

The impression of unimportance is reinforced because the coefficients change signs depending on the specification and the dependent variable. In addition, none of the coefficients differ from zero at even the 15-percent level. Finally, based on an F-test, the hypothesis that all the digital coefficients are zero cannot be rejected.

This result should not be interpreted as implying that digital processors are free or are of no consequence. The period covered by this study, 1970 through 1985, was one of sharply falling microprocessor prices and rapidly expanding technology. The result more likely suggests an alternative measure, not compounded by changing prices, would better capture the complexity associated with the digital technology. One such measure, not available for this study, would be the lines of code required for the processor.

BACKLOG/SALES RATIO

The BACKLOG/SALES RATIO variable also appears to be of little consequence in this sample. The elasticity estimates range from a low of 0.1 to a high of 0.17, which would suggest that a 10-percent increase in the firm's business could generate a 1- to 1.7-percent increase in the price of the system. With two exceptions, these estimates do not appear to be significantly different from zero.

The signs of the individual coefficients are consistent across the models although none are significant at the 10-percent level. The shift parameter ρ_{12} is positive, implying higher prices with higher levels of order backlogs relative to sales. This effect is reduced the greater the level of the firm's experience with the system (i.e., the greater the cumulative quantity. This comes as no particular surprise, as large cumulative quantities would imply the firm has already made a commitment to the program. The effect is compounded the larger the annual buy, because the larger annual quantity puts more pressure on the firm's resources.

Although an F-test implies that this variable can be dispensed with while modeling the contract price, the consistency of the results in this case suggests that this is a potentially important measure of the conditions faced by the firm. One factor is that the value of the backlog/sales variable used here is for the entire firm. A more appropriate measure would be for the division or profit center associated with the program, as that is typically the

level at which the pricing decisions are made. This is particularly true for firms that are large conglomerates, because the conditions in a particular division can be disguised by the total firm measure.

RANGE

The results of the elasticity estimates suggest that the range of the missile clearly has a positive effect on the price. For specification $\mathcal{L}$ the estimates range from 0.63 to 0.77, and all the estimates are greater than 8 times their respective estimated standard errors. For specification $\mathcal{A}$ the range is from 0.79 to 1.8.

Although the elasticity results are unambiguous, the estimates of the individual effects are mixed. Under specification $\mathcal{L}$ the effects of an increase in range, measured as the natural log of range, appear primarily as an upward shift in the price with a decrease in the price improvement parameter. The measured effects on the annual buy parameter are variable in both magnitude and sign and not different from zero. Under specification $\mathcal{A}$ where the range is measured in miles, the principle effect of range appears to be through its effect on the annual buy parameter.

The results obtained under $\mathcal{L}$ appear to be more sensible. The observed effect is consistent with a higher cost of obtaining greater range in which the cost is amortized over the life of the project, with the more rapid cost recovery occurring early in the program when the risk of the program being cancelled may be greater.

AURD

The AURD variable was included to account for those systems in which the only information available was on an all-up-round. The elasticity estimates range from -0.206 to 0.229 and are typically smaller than their associated standard errors. This is clearly a case in which the specification needs to be investigated further. Two systems are purchased as all-up-rounds in the data set: the Hellfire, which is a simple, laser-guided antitank missile, and the Patriot, a digital, radar-guided air defense missile. These systems are at opposite ends of the spectrum in terms of complexity, quantities purchased, and prices.

The insignificant results are driven by the estimated effect of cumulative quantity on the shift in price due to an all-up-round. In all models the estimate of shift (i.e., the value of ρ_5) is positive and significant. This positive shift is consistent with the purchase of the components added to the guidance and control unit to make an all-up-round. In addition, the negative effect on the price improvement parameter, measured by α_5, is consistent with learning during assembly.

PCNTPROG

The percent program variable was intended to measure the potential for "end-gaming" on the part of the contractors; that is, as the program approaches completion, the contractor sees the government as a captive consumer and raises prices since the government has relatively few options. The elasticity estimates are positive, which is consistent with the end-game hypothesis. However, they are not significantly different from zero.

The estimates of the individual coefficients are mixed. The shift parameter, ρ_7, is relatively large and positive for $\mathcal{L}$, small and negative for $\mathcal{A}$, and insignificant in all cases. The coefficient on the interaction between the percent program and the cumulative quantity is negative in all cases and significant under $\mathcal{L}$. The percent program annual buy interaction coefficient is positive in all cases and significant in all cases for $\mathcal{A}$ and in two cases for $\mathcal{L}$. The results suggest that end-gaming is reduced somewhat by experience and increased with the size of the annual buy. The reason for the effect of experience on end-gaming is not clear. However, the effect of the annual buy seems to be clear, as the larger the annual buy the greater the reward from successfully raising the price.

CAPIP

The CAPIP variable summarizes program history and recent behavior. Higher values of CAPIP appear to be associated with higher prices. The elasticity estimates range from 0.245 to 0.027. The estimates are significant for all case 1 estimates and for case 2 estimates under $\mathcal{L}$.

The elasticity effects are generated, primarily, by a large and significant positive shift, measured by ρ_8. The effect of cumulative quantity is mixed and insignificant. The effect of the annual buy is negative and, under $\mathcal{A}$, significant. These results suggest that establishing a high initial price and low rate of price improvement are useful to the firm and that larger annual buys mitigate, somewhat, the history of the program.

The CAPIP variable is not a satisfactory measure of the program history because it is difficult to interpret. Its significance suggests, however, that the program history is an important factor in determining the current contract price.

RCF

The estimates of the effects of cash flow on the price of a system are mixed. In general, the elasticity estimates are negative, small in absolute value, and not different from zero. The predominance of negative estimates is somewhat surprising, as the relationship between cash-flow and price was expected to be positive.

An examination of the coefficients shows a shift parameter, ρ_{10}, that is small, negative, and significant; cumulative quantity effects that are mixed and insignificant; and annual buy effects that are small and positive.

WPN

The WPN variable shows one of the strongest relationships with the contract price. The values of the elasticity of the nominal price, $\ln P$, range from 1.37 to 2.13, and values of the elasticity for the deflated price, $\ln P_{FY84}$, ranging from 0.45 to 0.95. All of the elasticity estimates are significant at the 0.10 level. One conclusion based on this result is that for this sample (i.e., these systems over the years 1970 through 1985) the price of missiles rose faster than the price of Naval weapons in general, as measured by the WPN index.

The shift effect of the WPN variable is clearly positive. The quantity effects are mixed. Under $\mathcal{L}$, there is a positive effect of cumulative quantity and a negative effect of annual buy. Under $\mathcal{A}$, cumulative quantity has a negative effect and annual buy has a positive effect.

CUMQ

The elasticity of price with respect to the cumulative output is the price improvement parameter. The price improvement parameter is calculated from the following:

$$\begin{aligned} \alpha &= \alpha_0 + \alpha_1 DIG + \alpha_2 RANGE + \alpha_3 SSFC + \alpha_4 COMP + \alpha_5 AURD \\ &\quad + \alpha_6 DEQ + \alpha_7 PCTPROG + \alpha_8 CAPIP + \alpha_9 WPN + \alpha_{10} RCF \\ &\quad + \alpha_{11} DODPCNT + \alpha_{12} BLOGSALE + \alpha_{13} \ln CUMQ \end{aligned} \tag{28}$$

The estimates of the price improvement parameter computed according to 28 range from -0.164 to -0.517. The smaller absolute values are associated with $\mathcal{L}$, the larger with $\mathcal{A}$.

Under specification $\mathcal{L}$, the α parameters for RANGE, AURD, PCNTPROG, WPN, and COMP were significant. The WPN parameter, α_9, was the only consistently positive parameter. Under specification $\mathcal{A}$, the significant parameters were the constant, α_0, the AURD parameter, the WPN parameter, and the coefficient on LCUMQ, α_{13}. In this case the WPN parameter changes sign and becomes negative.

BUY

The elasticity of the price with respect to the size of the annual buy is often called the rate parameter and is computed from

$$\begin{aligned}\beta &= \beta_0 + \beta_1 DIG + \beta_2 RANGE + \beta_3 SSFC + \beta_4 COMP + \beta_5 AURD \\ &\quad + \beta_6 DEQ + \beta_7 PCTPROG + \beta_8 CAPIP + \beta_9 WPN + \beta_{10} RCF \\ &\quad + \beta_{11} DODPCNT + \beta_{12} BLOGSALE + \beta_{13} \ln BUY \quad . \end{aligned} \tag{29}$$

Over half the elasticity estimates are negative but only three are significantly different from zero. The positive estimates of the elasticity are associated with the large annual buys of case 2 under specification $\mathcal{L}$. It is not particularly surprising that the annual buy has a relatively minor direct effect on the price. For many programs the annual buy during the major period of acquisition will not vary much from year to year, and this lack of variation will reduce the ability of regression analysis to identify the effects of the variable. For the most part the quantity variation within a program will be due to small quantities that occur at the beginning as the program gets started and at the end as the program winds down. In these instances many other factors may be expected to dominate any effects of the annual buy on the contract price.[33]

Although the direct effect of the annual buy does not appear to be significant, an examination of the interaction terms reveals some significant effects. Under $\mathcal{L}$ the constant term, β_0, RCF, DODPCNT, DEQ, and SSFC are all significant. The constant, DODPCNT and SSFC variables are all negative. Under $\mathcal{A}$, the significant variables are RANGE, PCNTPROG, CAPIP, WPN, DODPCNT, DEQ, and BUY, β_{13}, with CAPIP, DODPCNT, and BUY having negative signs. The significance of the interaction terms is that the annual buy can reduce or reinforce the effects of these other factors. Consequently, the annual buy is clearly an important consideration in the price of a particular contract for a weapon.

DODPCNT

The DODPCNT variable, which is the ratio of the dollar value of DOD contract awards in the current fiscal year to the current year sales, is also an important variable in determining price. The elasticity estimates, all of which are significant, range from -0.211 to -0.684. These estimates suggest that a 10-percent increase in the DOD share of a firm's business will result in a 2- to 7-percent decrease in the price.

[33] A clearer understanding of the direct effect of the annual buy on contract price is potentially available from the application of this analysis to the stair-step bids made by firms.

An examination of the individual coefficients associated with the DODPCNT variable suggests that the actual elasticity is critically dependent on the size of the annual buy. In fact estimates of the shift term associated with DODPCNT range from 4.323 to 5.218. These estimates would suggest a substantially higher price in more defense intensive firms. However, a further examination of the coefficients indicates that the size of the annual buy plays a crucial role in mitigating this tendancy toward a higher price; the estimates of the buy parameter, β_{11}, range from -0.728 to -1.061. All of the shift and annual buy parameters are significant. The cumulative quantity parameter is not significant in any of the models.

DEQ

The development estimate of quantity, DEQ, is the total quantity of missiles expected to be produced during the lifetime of the program. The expectation is based on estimates made just before the first production contract award. The elasticity estimates for the DEQ variable are unambiguously negative, indicating that an increase in the expected size of the program is associated with a decrease in the price. The estimates range from -0.213 to -0.732 suggesting that a 10-percent increase in the development estimate of the program quantity will result in a 2- to 7-percent decrease in the price.

As with the DODPCNT effect, the DEQ effect can be decomposed into component parts. The main effect is found in the negative and significant shift parameter.[34] This negative effect is reduced by the two quantity variables. In the case of cumulative quantity the effect is small and not significant. In the case of the annual buy the effect is larger for both specifications and significant for all the models under specification $\mathcal{L}$.

SSFC

Evaluating the effects of future competition shows that future competition appears to raise the current price relative to what would be expected from an otherwise identical sole-source program. The elasticity estimates are all positive. Also, the effect is stronger for case 1 with its small quantities than for case 2 with the larger quantities.

The decomposition of the elasticity estimate into its component parts provides further information on contract prices during the sole-source phase of a competitive program. Here, the contract prices associated with the SSFC variable are significantly higher than those associated with a pure sole source. The shift parameter, ρ_3, ranges from 4.3 to 6.6.

[34]The sharp differences in the parameter estimates between the two specifications are due to the units of measure. Under specification $\mathcal{A}$, the measure is the number of units, whereas under specification $\mathcal{L}$, the measure is the natural logarithm of the number of units.

The interaction terms, α_3 and β_3, are negative in all cases, but only β_3 is ever significant and then only under specification $\mathcal{L}$.

The interpretation of the SSFC effect is subject to competing hypotheses that differ in both causality and policy implications. The first hypothesis assumes that firms are skimming in anticipation of competiton. The direction of causality is from impending competition to the higher current price. For the firm that sees competition as almost inevitable, skimming may provide indirect benefits during the competitive period in addition to higher current prices. The firm, by showing high rates of price improvement and strong annual buy effects, may be able to establish favorable minimum quantity guarantees during the competitive phase. The negative values of α_3 and β_3 are consistent with this strategy.

Under the second hypothesis the direction of causality runs from higher prices to competition. In this scenario the higher prices are indications of problem programs in which competition was introduced in an effort to (re)gain control. The data used in this study do not contain sufficient information to distinguish between these two competing hypotheses.

COMP

The effect of competition on the contract price relative to a base-case sole-source contract is similar to that of the SSFC parameter. The price appears to be higher under competition than would be expected for an otherwise identical sole-source contract. The competition effect can be decomposed into its component parts.

The source of the positive effect of competition is found in the estimates of the shift parameter, ρ_4, which range from 1.74 to 4.17. The competition parameters associated with the cumulative quantity and the percent program completed are negative and generally insignificant. The estimates of the annual buy effect are of mixed sign, negative for $\mathcal{L}$ and positive for $\mathcal{A}$, and small in magnitude.

The preceding discussion defines the effects of competition relative to a base-case sole-source program, and if that were the only standard of comparison competition would not appear particularly beneficial in terms of its effects on the contract price. However, an alternative standard of comparison is found in the sole-source contracts before competition. Using the SSFC contracts as the standard of comparison results in an estimate of the effects of competition before and after its introduction.

Table 7 reports the specific competition parameters and elasticities when the base contract is a sole-source contract in a program that is ultimately subject to competition.[35]

[35] The estimates in table 7 were obtained by subtracting the SSFC parameter from the corresponding COMP parameter; for example, the value of the QCOMP parameters in table 7 are obtained by subtracting the QSSFC parameter in table 6 from the associated QCOMP parameter in table 6.

TABLE 7

IMPLIED COMPETITION—PARAMETERS AND ELASTICITIES
(SSFC as the base case)

	Model											
	1.$\mathcal{L}$.N(R)	2.$\mathcal{L}$.N(R)	3.$\mathcal{L}$.N(R)	4.$\mathcal{L}$.N(R)	1.$\mathcal{A}$.N	1.$\mathcal{A}$.R	2.$\mathcal{A}$.N	2.$\mathcal{A}$.R	3.$\mathcal{A}$.N	3.$\mathcal{A}$.R	4.$\mathcal{A}$.N	4.$\mathcal{A}$.R
Parameters												
COMP	-2.828	-2.772	-2.459	-2.458	-2. 460	-2.711	-2.445	-2.687	-2.016	-2.276	-2.000	-2.292
QCOMP	-0.058	-0.132	-0.143	-0.203	0.124	0.117	-.063	0.071	0.074	0.061	-0.001	0.018
BUYCOMP	0.493	0.563	0.523	0.591	0.253	0.296	0.320	0.343	0.243	0.289	0.322	0.341
COMPCTPR	-0.220	-0.126	-0.138	-0.0594	-0.413	-0.455	-0.306	-0.316	-0.375	-0.399	-0.254	-0.275
Elasticities												
Case 1	-0.194	-0.186	-0.198	-0.197	0.003	-0.040	0.003	-0.030	-0.009	-0.037	0.001	-0.031
Case 2	0.107	0.111	0.066	0.071	0.265	0.246	0.268	0.256	0.228	0.206	0.224	0.218

In examining the implied parameter estimates in table 7, several factors are notable. First, the effect of competition on the contract price relative to the preceding sole-source contracts has a large negative component with the estimates of the shift ranging from -2.0 to -2.8. Second, the estimates of the effect of cumulative quantity are mixed. Third, a consistently positive effect is associated with the annual buy that for large buys dominates the shift effect of competition.

One conclusion that can be drawn with respect to competition is that the effects are, at best, mixed. But, if concentration is focused on the shift parameters, which are generally significant, then, to the extent that the problem program hypothesis accurately describes the reasons for the introduction of competition, a clear potential exists for competition to provide benefits. This is particularly true if competition motivates and generates solutions to the problems that may plague a program.

CONCLUSIONS

This project set out to explore price formation in the DOD acquisition process and the effects of competition on prices. The impetus for this project arose from a study of empirical models of competition that seemed clearly inadequate due to their small sample sizes and their failure to consider the characteristics of the systems being acquired and the firms involved in the competition. A model, appropriate for the use of pooled cross-section, time-series data, was developed based on an examination of the institional structure of the defense acquisition process and the characteristics of the systems and firms involved.

The goals of this exploratory project have been attained. The feasibilty of the cross-sectional approach has been demonstrated. Conventional measures of the goodness-of-fit are highly significant. In addition, the issue of heteroscedasticity has been addressed and, based on Bartlett's test, rejected. This is an area, though, in which further research is necessary for any follow-on work, as Bartlett's test is only one approach to the issue of heteroscedasticity. However, a complete examination of the structure of the variance of contract prices was outside the scope of this exploratory project.

In evaluating the technical variables included in the model, the range of the missile is clearly an important factor in determining price; however, the specific channels through which range functions depend on the particular specification.

Of the firm-specific variables, the ratio of current DOD contracts to current sales appears to be important. Although it does not appear significant, the consistency across models of the backlog/sales ratio variable does suggest that further research in this area would be useful.

Many program-specific variables appear to be important. These include the WPN deflator, the Development Estimate of Quantity, the CAPIP variable, the annual buy, the cumulative quantity, the existence of a sole-source phase before competition, and the existence of competition.

The evaluation of the price effect of competition depends on many factors that were not available in this study. The most important is the question of whether the competitive programs used here were subject to competition because they were problem programs. If the answer is yes, then the estimates suggest that competition may have benefited those programs. If the answer is no, then the best that can be said is that competition may not have hurt.[36]

The problem program issue is important in another respect. If the higher prices before competition reflected increased expenditures directed at solving unexpected quality,

[36] An additional qualifier on the effects of competition is that the estimates discussed here are only partial effects and do not include the potential effects of quantity changes as the program profile was adjusted for the introduction of competition.

reliability, or schedule problems resolved with competition, then the effective price of the weapon is reduced by competition even when the contract price is not. The best example of this can be seen by comparing extremes. Which system has a lower effective price, one that never functions as required or one that functions as required but requires 10 percent more money?

Another aspect of competition, not addressed here, is the credibility of the competitor. The contract awards classified as competitive in this study reflect the classification provided by the program offices that supplied the data. With the exception of the HARM missile, all competitive awards were made under the conditions of dual sourcing, that is, two firms producing the system simultaneously. However, a substantial body of economic literature is devoted to the lack of competition when a small number of firms exist and the conditions under which having two producers can result in competition.[37] Consequently, an important question is under what conditions will a competitive contract award result in competitive prices.

Finally, with respect to the price effects of competition it is important to provide a caveat about the period from which the data are drawn and upon which the model of price formation is based, the years 1965 through 1985. For most of the period (from 1970 to 1980), the preferred acquisition method for major systems appears to have been the negotiated sole-source award. Competition occurred at the early design or development stage, if it occurred at all. Consequently, defense contractors of the era would be expected to form their pricing strategies in the light of this approach to procurement by DOD.[38] The introduction of competition as the preferred method of procurement, which is codified in the Competition in Contracting Act, CICA, can be expected to cause at least two changes in the price determination process. The first change will be in the way the government conducts its acquisitions since competition can be expected to place different demands on the government procurement agencies. The second effect will be in the way firms price their products. Given the evolutionary nature of this change in the structure of the defense procurement process, the applicability of the pre-CICA data in evaluating the effects of competition is likely to decline.

Overall, the conclusion is that the cross-sectional approach is feasible and provides a rich field for further research. In particular, the effects of the Competition in Contracting Act and other legislation as they pertain to the general structure of acquisition may be amenable to a cross-section approach.

Given that a major conclusion of this work is that further research is called for, a final comment on the direction of follow-on efforts is appropriate. Further research into the acquisition process and the effects of competition should not be confined to the narrow

[37] Beltramo [27] contains a good discussion of the possibilities in a defense procurement context.

[38] The buy-in, where a firm bids low in the initial stages of a program to gain access, is clearly a strategy consistent with this era.

dimension of price alone. The importance placed by the government on system performance and quality implies that these factors must be included in any complete model of the aquisition process. It is possible that greater effects of competition may be found along the schedule and performance dimensions rather than, or at least in addition to, the price dimension. Further research should also examine the effects of policy on the variances and covariances of price, performance, and schedule. A policy that reduces the variances along the price, performance, or schedule dimension may be a success even if it fails to improve the associated mean.

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TABLE A–1

REGRESSION RESULTS:
Model 1, SPECIFICATION– $\mathcal{L}$, DEP VARIABLE– $\ln P$

ANALYSIS OF VARIANCE				
SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE
Model	41	133.19	3.25	169.21
ERROR	38	0.730	0.0192	(0.0001)
C TOTAL	79	133.92		
R-SQUARE	0.995	ADJ R-SQ	0.989	

PARAMETER ESTIMATES				
VARIABLE	PARAMETER ESTIMATE	STANDARD ERROR	T FOR H_0: PARAMETER=0	PROB > $\|T\|$
INTERCEPT	27.577	4.372	6.308	0.0001
DIG	0.369	0.841	0.439	0.6628
QDIG	-0.0974	0.201	-0.485	0.6302
BUYDIG	0.0880	0.268	0.328	0.7447
LRANGE	1.297	0.559	2.319	0.0259
QRANG	-0.0786	0.0710	-1.106	0.2755
BUYRANG	-0.00270	0.0999	-0.027	0.9785
SSFC	6.600	1.0785	6.119	0.0001
QSSFC	-0.314	0.225	-1.392	0.1721
BUYSSFC	-0.534	0.298	-1.793	0.0809
COMP	3.732	1.214	3.075	0.0039
QCOMP	-0.372	0.227	-1.639	0.1095
BUYCOMP	-0.0414	0.234	-0.177	0.8602
COMPCTPR	-0.220	0.308	-0.715	0.4788
AURD	2.341	0.736	3.183	0.0029
QAURD	-0.311	0.139	-2.243	0.0308
BUYAURD	0.0317	0.208	0.152	0.8797
LDEQ	-3.697	0.606	-6.099	0.0001
QDEQ	0.0358	0.139	0.258	0.7980
BUYDEQ	0.424	0.172	2.465	0.0183
PCNTPROG	1.873	1.722	1.088	0.2836
QPCTPROG	-0.368	0.172	-2.139	0.0389
BYPCTPRG	0.209	0.140	1.499	0.1421
CAPIP	2.715	1.397	1.944	0.0594
QCAPIP	-0.118	0.264	-0.449	0.6561
BUYCAPIP	-0.107	0.345	-0.310	0.7582
LWPN	0.934	1.246	0.750	0.4578
QWPN	0.394	0.223	1.770	0.0848
BUYWPN	-0.373	0.269	-1.386	0.1737
RCF	-0.00333	0.00147	-2.260	0.0296
QRCF	-0.000183	0.000297	-0.615	0.5420
BUYRCF	0.000666	0.000339	1.963	0.0570
DODPCNT	5.116	1.299	3.940	0.0003
QPCNT	-0.0370	0.164	-0.226	0.8226
BUYPCNT	-0.838	0.277	-3.027	0.0044
BLOGSALE	0.266	0.533	0.500	0.6202
QBLS	-0.0747	0.0672	-1.111	0.2736
BUYBLS	0.0618	0.0912	0.678	0.5021
LCUMQ	1.640	1.526	1.074	0.2894
Q2	-0.190	0.107	-1.768	0.0850
LBUY	-3.557	1.928	-1.845	0.0728
BUY2	-0.0845	0.113	-0.751	0.4571

TABLE A–2

REGRESSION RESULTS:
Model 1, SPECIFICATION– $\mathcal{L}$, DEP VARIABLE– $\ln P_{FY84}$

ANALYSIS OF VARIANCE				
SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE
Model	41	128.827	3.142	163.67
ERROR	38	0.730	0.0192	(0.0001)
C TOTAL	79	129.557		
R-SQUARE	0.9944	ADJ R-SQ	0.9883	

PARAMETER ESTIMATES				
VARIABLE	PARAMETER ESTIMATE	STANDARD ERROR	T FOR H_0: PARAMETER=0	PROB > $\|T\|$
INTERCEP	27.577	4.372	6.308	0.0001
DIG	0.369	0.841	0.439	0.6628
QDIG	-0.0974	0.201	-0.485	0.6302
BUYDIG	0.0880	0.268	0.328	0.7447
LRANGE	1.297	0.559	2.319	0.0259
QRANG	-0.0786	0.0710	-1.106	0.2755
BUYRANG	-0.00270	0.0999	-0.027	0.9785
SSFC	6.600	1.078	6.119	0.0001
QSSFC	-0.314	0.225	-1.392	0.1721
BUYSSFC	-0.534	0.298	-1.793	0.0809
COMP	3.732	1.214	3.075	0.0039
QCOMP	-0.372	0.227	-1.639	0.1095
BUYCOMP	-0.0414	0.234	-0.177	0.8602
COMPCTPR	-0.220	0.308	-0.715	0.4788
AURD	2.341	0.736	3.183	0.0029
QAURD	-0.311	0.139	-2.243	0.0308
BUYAURD	0.0317	0.208	0.152	0.8797
LDEQ	-3.697	0.606	-6.099	0.0001
QDEQ	0.0358	0.139	0.258	0.7980
BUYDEQ	0.424	0.172	2.465	0.0183
PCNTPROG	1.873	1.722	1.088	0.2836
QPCTPROG	-0.368	0.172	-2.139	0.0389
BYPCTPRG	0.209	0.140	1.499	0.1421
CAPIP	2.715	1.397	1.944	0.0594
QCAPIP	-0.118	0.264	-0.449	0.6561
BUYCAPIP	-0.107	0.345	-0.310	0.7582
LWPNESC	-0.0656	1.246	-0.053	0.9582
QWPN	0.394	0.223	1.770	0.0848
BUYWPN	-0.373	0.269	-1.386	0.1737
RCF	-0.00333	0.00147	-2.260	0.0296
QRCF	-0.000183	0.000297	-0.615	0.5420
BUYRCF	0.000666	0.000339	1.963	0.0570
DODPCNT	5.116	1.299	3.940	0.0003
QPCNT	-0.0370	0.164	-0.226	0.8226
BUYPCNT	-0.838	0.277	-3.027	0.0044
BLOGSALE	0.266	0.533	0.500	0.6202
QBLS	-0.0747	0.0672	-1.111	0.2736
BUYBLS	0.0618	0.0912	0.678	0.5021
LCUMQ	1.640	1.526	1.074	0.2894
Q2	-0.190	0.107	-1.768	0.0850
LBUY	-3.557	1.928	-1.845	0.0728
BUY2	-0.0845	0.113	-0.751	0.4571

TABLE A-3

REGRESSION RESULTS:
Model 2, SPECIFICATION– $\mathcal{L}$, DEP VARIABLE– $\ln P$

ANALYSIS OF VARIANCE				
SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE
Model	38	133.102	3.503	175.825
ERROR	41	0.817	0.0199	(0.0001)
C TOTAL	79	133.919		
R-SQUARE	0.9939	ADJ R-SQ	0.9882	

PARAMETER ESTIMATES				
VARIABLE	PARAMETER ESTIMATE	STANDARD ERROR	T FOR H_0: PARAMETER=0	PROB > $\|T\|$
INTERCEPT	27.958	4.099	6.821	0.0001
LRANGE	1.627	0.363	4.479	0.0001
QRANG	-0.125	0.0648	-1.932	0.0603
BUYRANG	0.0117	0.0869	0.134	0.8938
SSFC	6.944	1.083	6.410	0.0001
QSSFC	-0.301	0.229	-1.316	0.1956
BUYSSFC	-0.608	0.300	-2.026	0.0493
COMP	4.172	1.203	3.467	0.0013
QCOMP	-0.433	0.228	-1.901	0.0644
BUYCOMP	-0.0459	0.234	-0.196	0.8454
COMPCTPR	-0.126	0.308	-0.410	0.6842
AURD	2.336	0.664	3.520	0.0011
QAURD	-0.236	0.136	-1.735	0.0903
BUYAURD	-0.0734	0.194	-0.379	0.7067
LDEQ	-3.833	0.604	-6.345	0.0001
QDEQ	0.0211	0.105	0.202	0.8413
BUYDEQ	0.460	0.131	3.506	0.0011
PCNTPROG	1.876	1.663	1.128	0.2659
QPCTPROG	-0.338	0.153	-2.205	0.0331
BYPCTPRG	0.155	0.0883	1.753	0.0870
CAPIP	2.885	1.345	2.145	0.0379
QCAPIP	-0.171	0.261	-0.657	0.5150
BUYCAPIP	-0.0461	0.346	-0.133	0.8947
LWPN	1.598	0.633	2.526	0.0155
QWPN	0.257	0.161	1.602	0.1169
BUYWPN	-0.284	0.188	-1.514	0.1378
RCF	-0.00263	0.00141	-1.858	0.0703
QRCF	-0.000199	0.000300	-0.664	0.5106
BUYRCF	0.000582	0.000336	1.735	0.0903
DODPCNT	4.916	1.062	4.628	0.0001
QPCNT	0.0115	0.164	0.070	0.9443
BUYPCNT	-0.868	0.264	-3.283	0.0021
BLOGSALE	0.298	0.525	0.567	0.5737
QBLS	-0.0677	0.0678	-1.000	0.3233
BUYBLS	0.0449	0.0920	0.488	0.6279
LCUMQ	1.467	1.228	1.195	0.2390
Q2	-0.154	0.105	-1.459	0.1523
LBUY	-3.409	1.468	-2.322	0.0253
BUY2	-0.125	0.111	-1.126	0.2668

TABLE A–4

REGRESSION RESULTS:
Model 2, SPECIFICATION– $\mathcal{L}$, DEP VARIABLE– $\ln P_{FY84}$

ANALYSIS OF VARIANCE				
SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE
Model	38	128.740	3.388	170.063
ERROR	41	0.817	0.0199	(0.0001)
C TOTAL	79	129.557		
R-SQUARE	0.9937	ADJ R-SQ	0.9879	

PARAMETER ESTIMATES				
VARIABLE	PARAMETER ESTIMATE	STANDARD ERROR	T FOR H_0: PARAMETER=0	PROB > $\|T\|$
INTERCEPT	27.958	4.099	6.821	0.0001
LRANGE	1.627	0.363	4.479	0.0001
QRANG	-0.125	0.0648	-1.932	0.0603
BUYRANG	0.0117	0.0869	0.134	0.8938
SSFC	6.944	1.083	6.410	0.0001
QSSFC	-0.301	0.229	-1.316	0.1956
BUYSSFC	-0.608	0.300	-2.026	0.0493
COMP	4.172	1.203	3.467	0.0013
QCOMP	-0.433	0.228	-1.901	0.0644
BUYCOMP	-0.0459	0.234	-0.196	0.8454
COMPCTPR	-0.126	0.308	-0.410	0.6842
AURD	2.336	0.664	3.520	0.0011
QAURD	-0.236	0.136	-1.735	0.0903
BUYAURD	-0.0734	0.194	-0.379	0.7067
LDEQ	-3.833	0.604	-6.345	0.0001
QDEQ	0.0211	0.105	0.202	0.8412
BUYDEQ	0.460	0.131	3.506	0.0011
PCNTPROG	1.876	1.663	1.128	0.2659
QPCTPROG	-0.338	0.153	-2.205	0.0331
BYPCTPRG	0.155	0.0883	1.753	0.0870
CAPIP	2.885	1.345	2.145	0.0379
QCAPIP	-0.171	0.261	-0.657	0.5150
BUYCAPIP	-0.0461	0.346	-0.133	0.8947
LWPN	0.598	0.633	0.946	0.3498
QWPN	0.257	0.161	1.602	0.1169
BUYWPN	-0.284	0.188	-1.514	0.1378
RCF	-0.00263	0.00141	-1.858	0.0703
QRCF	-0.000199	0.000300	-0.664	0.5106
BUYRCF	0.000582	0.000336	1.735	0.0903
DODPCNT	4.916	1.0624	4.628	0.0001
QPCNT	0.0115	0.164	0.070	0.9443
BUYPCNT	-0.868	0.264	-3.283	0.0021
BLOGSALE	0.298	0.525	0.567	0.5737
QBLS	-0.0677	0.0678	-1.000	0.3233
BUYBLS	0.0449	0.0920	0.488	0.6279
LCUMQ	1.467	1.228	1.195	0.2390
Q2	-0.154	0.105	-1.459	0.1523
LBUY	-3.409	1.468	-2.322	0.0253
BUY2	-0.125	0.111	-1.126	0.2668

TABLE A-5

REGRESSION RESULTS:
Model 3, SPECIFICATION– $\mathcal{L}$, DEP VARIABLE– $\ln P$

ANALYSIS OF VARIANCE				
SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE
Model	38	133.138	3.504	183.998
ERROR	41	0.781	0.0190	(0.0001)
C TOTAL	79	133.919		
R-SQUARE	0.9942	ADJ R-SQ	0.9888	

PARAMETER ESTIMATES				
VARIABLE	PARAMETER ESTIMATE	STANDARD ERROR	T FOR H_0: PARAMETER=0	PROB > $\|T\|$
INTERCEPT	26.356	3.847	6.851	0.0001
DIG	0.499	0.811	0.614	0.5423
QDIG	-0.0753	0.199	-0.379	0.7066
BUYDIG	0.0399	0.262	0.152	0.8796
LRANGE	1.218	0.541	2.250	0.0299
QRANG	-0.0603	0.0693	-0.869	0.3897
BUYRANG	-0.0136	0.0988	-0.138	0.8912
SSFC	6.179	0.886	6.974	0.0001
QSSFC	-0.218	0.212	-1.031	0.3087
BUYSSFC	-0.606	0.292	-2.077	0.0441
COMP	3.720	1.080	3.444	0.0013
QCOMP	-0.361	0.226	-1.598	0.1176
BUYCOMP	-0.0832	0.223	-0.374	0.7106
COMPCTPR	-0.138	0.296	-0.468	0.6423
AURD	2.266	0.692	3.273	0.0022
QAURD	-0.230	0.122	-1.885	0.0666
BUYAURD	-0.0674	0.187	-0.361	0.7201
LDEQ	-3.437	0.474	-7.245	0.0001
QDEQ	0.0116	0.133	0.087	0.9312
BUYDEQ	0.429	0.156	2.743	0.0090
PCNTPROG	2.388	1.622	1.472	0.1485
QPCTPROG	-0.423	0.160	-2.640	0.0117
BYPCTPRG	0.195	0.133	1.471	0.1489
CAPIP	2.227	1.307	1.704	0.0960
QCAPIP	0.00855	0.243	0.035	0.9722
BUYCAPIP	-0.189	0.337	-0.561	0.5777
LWPN	0.870	1.236	0.704	0.4854
QWPN	0.380	0.221	1.723	0.0924
BUYWPN	-0.349	0.266	-1.313	0.1965
RCF	-0.00259	0.00134	-1.928	0.0608
QRCF	-0.000190	0.000296	-0.644	0.5232
BUYRCF	0.000561	0.000328	1.713	0.0942
DODPCNT	5.074	1.047	4.844	0.0001
QPCNT	-0.104	0.142	-0.732	0.4681
BUYPCNT	-0.728	0.211	-3.441	0.0013
LCUMQ	1.356	1.502	0.903	0.3718
Q2	-0.140	0.0990	-1.413	0.1653
LBUY	-3.338	1.876	-1.779	0.0827
BUY2	-0.0987	0.107	-0.920	0.3631

TABLE A-6

REGRESSION RESULTS:
Model 3, SPECIFICATION– $\mathcal{L}$, DEP VARIABLE– $\ln P_{FY84}$

ANALYSIS OF VARIANCE				
SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE
Model	38	128.776	3.389	177.970
ERROR	41	0.781	0.0190	(0.0001)
C TOTAL	79	129.557		
R-SQUARE	0.9940	ADJ R-SQ	0.9884	

PARAMETER ESTIMATES				
VARIABLE	PARAMETER ESTIMATE	STANDARD ERROR	T FOR H_0: PARAMETER=0	PROB > $\|T\|$
INTERCEPT	26.356	3.847	6.851	0.0001
DIG	0.499	0.811	0.615	0.5423
QDIG	-0.0753	0.199	-0.379	0.7066
BUYDIG	0.0399	0.262	0.152	0.8796
LRANGE	1.218	0.541	2.250	0.0299
QRANG	-0.0603	0.0693	-0.869	0.3897
BUYRANG	-0.0136	0.0988	-0.138	0.8912
SSFC	6.179	0.886	6.974	0.0001
QSSFC	-0.218	0.212	-1.031	0.3086
BUYSSFC	-0.606	0.292	-2.077	0.0441
COMP	3.720	1.080	3.444	0.0013
QCOMP	-0.361	0.226	-1.598	0.1176
BUYCOMP	-0.0832	0.223	-0.374	0.7106
COMPCTPR	-0.138	0.296	-0.468	0.6423
AURD	2.266	0.692	3.273	0.0022
QAURD	-0.230	0.122	-1.885	0.0666
BUYAURD	-0.0674	0.187	-0.361	0.7201
LDEQ	-3.437	0.475	-7.245	0.0001
QDEQ	0.0116	0.133	0.087	0.9312
BUYDEQ	0.429	0.156	2.743	0.0090
PCNTPROG	2.388	1.622	1.472	0.1485
QPCTPROG	-0.423	0.160	-2.640	0.0117
BYPCTPRG	0.195	0.133	1.471	0.1489
CAPIP	2.227	1.307	1.704	0.0960
QCAPIP	0.00855	0.243	0.035	0.9722
BUYCAPIP	-0.189	0.337	-0.561	0.5777
LWPN	-0.130	1.236	-0.105	0.9167
QWPN	0.380	0.221	1.723	0.0924
BUYWPN	-0.349	0.266	-1.313	0.1965
RCF	-0.00259	0.00134	-1.928	0.0608
QRCF	-0.000190	0.000296	-0.644	0.5232
BUYRCF	0.000561	0.000328	1.713	0.0942
DODPCNT	5.074	1.047	4.844	0.0001
QPCNT	-0.104	0.142	-0.732	0.4681
BUYPCNT	-0.728	0.211	-3.441	0.0013
LCUMQ	1.356	1.502	0.903	0.3718
Q2	-0.140	0.0990	-1.413	0.1653
LBUY	-3.338	1.876	-1.779	0.0827
BUY2	-0.0987	0.107	-0.920	0.3631

TABLE A-7

REGRESSION RESULTS:
Model 4, SPECIFICATION– $\mathcal{L}$, DEP VARIABLE– $\ln P$

ANALYSIS OF VARIANCE				
SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE
Model	35	133.068	3.802	196.532
ERROR	44	0.851	0.0193	(0.0001)
C TOTAL	79	133.919		
R-SQUARE	0.9936	ADJ R-SQ	0.9886	

PARAMETER ESTIMATES				
VARIABLE	PARAMETER ESTIMATE	STANDARD ERROR	T FOR H_0: PARAMETER=0	PROB > $\|T\|$
INTERCEPT	26.758	3.610	7.413	0.0001
LRANGE	1.588	0.355	4.474	0.0001
QRANG	-0.104	0.0616	-1.688	0.0985
BUYRANG	-0.00851	0.0843	-0.101	0.9201
SSFC	6.449	0.864	7.467	0.0001
QSSFC	-0.217	0.213	-1.016	0.3150
BUYSSFC	-0.649	0.292	-2.227	0.0311
COMP	3.991	1.042	3.832	0.0004
QCOMP	-0.420	0.224	-1.873	0.0678
BUYCOMP	-0.0577	0.218	-0.265	0.7920
COMPCTPR	-0.0594	0.295	-0.202	0.8410
AURD	2.174	0.579	3.755	0.0005
QAURD	-0.174	0.119	-1.462	0.1507
BUYAURD	-0.132	0.171	-0.776	0.4420
LDEQ	-3.555	0.470	-7.568	0.0001
QDEQ	-0.00471	0.0966	-0.049	0.9613
BUYDEQ	0.461	0.115	4.025	0.0002
PCNTPROG	2.290	1.578	1.451	0.1538
QPCTPROG	-0.394	0.138	-2.858	0.0065
BYPCTPRG	0.159	0.0814	1.950	0.0576
CAPIP	2.416	1.242	1.946	0.0581
QCAPIP	-0.0652	0.239	-0.273	0.7863
BUYCAPIP	-0.106	0.333	-0.319	0.7514
LWPN	1.708	0.547	3.121	0.0032
QWPN	0.252	0.156	1.614	0.1137
BUYWPN	-0.297	0.181	-1.644	0.1073
RCF	-0.00215	0.00128	-1.684	0.0994
QRCF	-0.000195	0.000295	-0.660	0.5127
BUYRCF	0.000505	0.000322	1.569	0.1238
DODPCNT	4.880	0.849	5.749	0.0001
QPCNT	-0.0492	0.139	-0.353	0.7260
BUYPCNT	-0.772	0.196	-3.928	0.0003
LCUMQ	1.253	1.194	1.049	0.2998
Q2	-0.109	0.0952	-1.146	0.2579
LBUY	-3.237	1.413	-2.291	0.0268
BUY2	-0.136	0.104	-1.304	0.1990

TABLE A–8

REGRESSION RESULTS:
Model 4, SPECIFICATION– $\mathcal{L}$, DEP VARIABLE– $\ln P_{FY84}$

ANALYSIS OF VARIANCE				
SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE
Model	35	128.706	3.677	190.089
ERROR	44	0.851	0.0193	(0.0001)
C TOTAL	79	129.557		
R-SQUARE	0.9934	ADJ R-SQ	0.9882	

PARAMETER ESTIMATES				
VARIABLE	PARAMETER ESTIMATE	STANDARD ERROR	T FOR H_0: PARAMETER=0	PROB > $\|T\|$
INTERCEPT	26.758	3.610	7.413	0.0001
LRANGE	1.588	0.355	4.474	0.0001
QRANG	-0.104	0.0616	-1.688	0.0985
BUYRANG	-0.00851	0.0843	-0.101	0.9201
SSFC	6.449	0.864	7.467	0.0001
QSSFC	-0.217	0.213	-1.016	0.3150
BUYSSFC	-0.649	0.292	-2.227	0.0311
COMP	3.991	1.042	3.832	0.0004
QCOMP	-0.420	0.224	-1.873	0.0678
BUYCOMP	-0.0577	0.218	-0.265	0.7920
COMPCTPR	-0.0594	0.295	-0.202	0.8410
AURD	2.174	0.579	3.755	0.0005
QAURD	-0.174	0.119	-1.462	0.1507
BUYAURD	-0.132	0.171	-0.776	0.4420
LDEQ	-3.555	0.470	-7.568	0.0001
QDEQ	-0.00471	0.0966	-0.049	0.9613
BUYDEQ	0.461	0.115	4.025	0.0002
PCNTPROG	2.290	1.578	1.451	0.1538
QPCTPROG	-0.394	0.138	-2.858	0.0065
BYPCTPRG	0.159	0.0814	1.950	0.0576
CAPIP	2.416	1.242	1.946	0.0581
QCAPIP	-0.0652	0.239	-0.273	0.7863
BUYCAPIP	-0.106	0.333	-0.319	0.7514
LWPN	0.708	0.547	1.293	0.2026
QWPN	0.252	0.156	1.614	0.1137
BUYWPN	-0.297	0.181	-1.644	0.1073
RCF	-0.00215	0.00128	-1.684	0.0994
QRCF	-0.000195	0.000295	-0.660	0.5127
BUYRCF	0.000505	0.000322	1.569	0.1238
DODPCNT	4.880	0.849	5.749	0.0001
QPCNT	-0.0492	0.139	-0.353	0.7260
BUYPCNT	-0.772	0.196	-3.928	0.0003
LCUMQ	1.253	1.194	1.049	0.2998
Q2	-0.109	0.0952	-1.146	0.2579
LBUY	-3.237	1.413	-2.291	0.0268
BUY2	-0.136	0.104	-1.304	0.1990

TABLE A–9

REGRESSION RESULTS:
Model 1, SPECIFICATION– A, DEP VARIABLE– $\ln P$

ANALYSIS OF VARIANCE				
SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE
Model	41	133.251	3.250	184.743
ERROR	38	0.668	0.0176	(0.0001)
C TOTAL	79	133.919		
R-SQUARE	0.9950	ADJ R-SQ	0.9896	

PARAMETER ESTIMATES				
VARIABLE	PARAMETER ESTIMATE	STANDARD ERROR	T FOR H_0: PARAMETER=0	PROB > $\|T\|$
INTERCEPT	-0.648	2.588	-0.250	0.8036
DIG	0.106	0.725	0.146	0.8847
QDIG	0.0251	0.176	0.142	0.8875
BUYDIG	-0.0178	0.229	-0.078	0.9383
RANGE	-0.00174	0.0253	-0.069	0.9455
QRANG	-0.00291	0.00396	-0.735	0.4669
BUYRANG	0.0114	0.00563	2.026	0.0498
SSFC	4.453	0.997	4.466	0.0001
QSSFC	-0.308	0.200	-1.543	0.1310
BUYSSFC	-0.237	0.247	-0.961	0.3427
COMP	1.993	1.161	1.716	0.0942
QCOMP	-0.184	0.199	-0.920	0.3633
BUYCOMP	0.0156	0.198	0.079	0.9377
COMPCTPR	-0.413	0.282	-1.465	0.1512
AURD	1.243	1.013	1.227	0.2273
QAURD	-0.362	0.154	-2.349	0.0242
BUYAURD	0.245	0.300	0.818	0.4182
DEQ	-0.000212	.0000481	-4.411	0.0001
QDEQ	.00000723	.00000721	1.003	0.3220
BUYDEQ	.0000189	.0000113	1.676	0.1020
PCNTPROG	-0.296	1.742	-0.170	0.8659
QPCTPROG	-0.0935	0.188	-0.498	0.6212
BYPCTPRG	0.200	0.104	1.921	0.0623
CAPIP	5.417	1.405	3.856	0.0004
QCAPIP	0.0471	0.245	0.192	0.8487
BUYCAPIP	-0.782	0.312	-2.507	0.0166
WPN	3.060	1.645	1.861	0.0706
QWPN	-0.524	0.325	-1.611	0.1155
BUYWPN	0.486	0.390	1.247	0.2199
RCF	-0.00364	0.00151	-2.405	0.0211
QRCF	0.000135	0.000296	0.457	0.6505
BUYRCF	0.000374	0.000342	1.095	0.2803
DODPCNT	4.962	1.299	3.820	0.0005
QPCNT	0.123	0.167	0.737	0.4659
BUYPCNT	-0.997	0.253	-3.933	0.0003
BLOGSALE	0.0664	0.496	0.134	0.8942
QBLS	-0.0432	0.0631	-0.684	0.4978
BUYBLS	0.0563	0.0883	0.637	0.5278
LCUMQ	1.473	0.684	2.155	0.0376
Q2	-0.198	0.0994	-1.994	0.0533
LBUY	0.153	0.810	0.189	0.8514
BUY2	-0.163	0.115	-1.421	0.1636

TABLE A–10

REGRESSION RESULTS:
Model 1, SPECIFICATION– A, DEP VARIABLE– $\ln P_{FY84}$

ANALYSIS OF VARIANCE				
SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE
Model	41	128.934	3.145	191.941
ERROR	38	0.623	0.0164	(0.0001)
C TOTAL	79	129.557		
R-SQUARE	0.9952	ADJ R-SQ	0.9900	

PARAMETER ESTIMATES				
VARIABLE	PARAMETER ESTIMATE	STANDARD ERROR	T FOR H_0: PARAMETER=0	PROB > $\|T\|$
INTERCEPT	0.512	2.498	0.205	0.8386
DIG	-0.491	0.700	-0.702	0.4870
QDIG	0.131	0.170	0.771	0.4457
BUYDIG	-0.0447	0.221	-0.203	0.8405
RANGE	0.00481	0.0244	0.197	0.8451
QRANG	-0.00554	0.00382	-1.448	0.1557
BUYRANG	0.0133	0.00544	2.451	0.0189
SSFC	4.451	0.962	4.625	0.0001
QSSFC	-0.279	0.193	-1.447	0.1562
BUYSSFC	-0.262	0.238	-1.098	0.2790
COMP	1.740	1.120	1.553	0.1287
QCOMP	-0.162	0.192	-0.842	0.4050
BUYCOMP	0.0340	0.191	0.178	0.8598
COMPCTPR	-0.455	0.272	-1.672	0.1026
AURD	0.715	0.978	0.732	0.4689
QAURD	-0.317	0.149	-2.131	0.0396
BUYAURD	0.287	0.289	0.993	0.3272
DEQ	-0.000213	.0000464	-4.582	0.0001
QDEQ	.00000936	.00000696	1.345	0.1865
BUYDEQ	.0000164	.0000109	1.508	0.1399
PCNTPROG	-0.182	1.681	-0.108	0.9146
QPCTPROG	-0.0820	0.181	-0.453	0.6533
BYPCTPRG	0.191	0.100	1.901	0.0650
CAPIP	5.846	1.356	4.312	0.0001
QCAPIP	-0.118	0.236	-0.500	0.6203
BUYCAPIP	-0.664	0.301	-2.208	0.0333
WPN	2.201	1.587	1.387	0.1736
QWPN	-0.669	0.314	-2.130	0.0397
BUYWPN	0.564	0.376	1.499	0.1420
RCF	-0.00339	0.00146	-2.320	0.0258
QRCF	0.000150	0.000286	0.525	0.6028
BUYRCF	0.000317	0.000330	0.961	0.3428
DODPCNT	4.446	1.254	3.546	0.0011
QPCNT	0.111	0.161	0.688	0.4955
BUYPCNT	-0.906	0.244	-3.706	0.0007
BLOGSALE	0.215	0.479	0.450	0.6555
QBLS	-0.0563	0.0609	-0.923	0.3617
BUYBLS	0.0479	0.0852	0.563	0.5770
LCUMQ	1.613524	0.660	2.445	0.0192
Q2	-0.214	0.0959	-2.234	0.0314
LBUY	0.0862	0.782	0.110	0.9128
BUY2	-0.161	0.111	-1.450	0.1552

TABLE A–11

REGRESSION RESULTS:
Model 2, SPECIFICATION– A, DEP VARIABLE– ln P

ANALYSIS OF VARIANCE				
SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE
Model	38	133.209	3.506	202.486
ERROR	41	0.710	0.0173	(0.0001)
C TOTAL	79	133.919		
R-SQUARE	0.9947	ADJ R-SQ	0.9898	

PARAMETER ESTIMATES				
VARIABLE	PARAMETER ESTIMATE	STANDARD ERROR	T FOR H_0: PARAMETER=0	PROB > $\lvert T\rvert$
INTERCEPT	-1.414	2.303	-0.614	0.5428
RANGE	0.000328	0.0180	0.018	0.9855
QRANG	-0.00367	0.00341	-1.077	0.2880
BUYRANG	0.0124	0.00478	2.599	0.0129
SSFC	4.827	0.942	5.127	0.0001
QSSFC	-0.328	0.195	-1.681	0.1003
BUYSSFC	-0.282	0.237	-1.189	0.2414
COMP	2.382	1.101	2.164	0.0363
QCOMP	-0.265	0.187	-1.417	0.1641
BUYCOMP	0.0377	0.185	0.203	0.8401
COMPCTPR	-0.306	0.270	-1.134	0.2635
AURD	1.657	0.869	1.905	0.0638
QAURD	-0.286	0.144	-1.990	0.0533
BUYAURD	0.0750	0.262	0.287	0.7759
DEQ	-0.000230	.0000460	-4.998	0.0001
QDEQ	.00000603	.00000631	0.957	0.3444
BUYDEQ	.0000232	.00000999	2.322	0.0253
PCNTPROG	0.00416	1.548	0.003	0.9979
QPCTPROG	-0.119	0.158	-0.755	0.4547
BYPCTPRG	0.176	0.0824	2.133	0.0390
CAPIP	5.637	1.283	4.393	0.0001
QCAPIP	0.0164	0.237	0.069	0.9453
BUYCAPIP	-0.768	0.304	-2.525	0.0155
WPN	3.465	0.866	4.002	0.0003
QWPN	-0.553	0.255	-2.164	0.0364
BUYWPN	0.502	0.296	1.697	0.0973
RCF	-0.00341	0.00132	-2.576	0.0137
QRCF	.0000621	0.000289	0.215	0.8308
BUYRCF	0.000417	0.000315	1.322	0.1934
DODPCNT	5.036	0.989	5.094	0.0001
QPCNT	0.159	0.159	1.003	0.3219
BUYPCNT	-1.061	0.233	-4.549	0.0001
BLOGSALE	0.152	0.420	0.361	0.7197
QBLS	-0.0510	0.0588	-0.868	0.3907
BUYBLS	0.0514	0.0866	0.593	0.5562
LCUMQ	1.343	0.672	1.999	0.0523
Q2	-0.171	0.0968	-1.762	0.0855
LBUY	0.443	0.770	0.575	0.5686
BUY2	-0.209	0.109	-1.921	0.0617

TABLE A–12

REGRESSION RESULTS:
Model 2, SPECIFICATION– A, DEP VARIABLE– ln P_{FY84}

ANALYSIS OF VARIANCE				
SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE
Model	38	128.864	3.391	200.612
ERROR	41	0.693	0.0169	(0.0001)
C TOTAL	79	129.557		
R-SQUARE	0.9947	ADJ R-SQ	0.9897	

PARAMETER ESTIMATES				
VARIABLE	PARAMETER ESTIMATE	STANDARD ERROR	T FOR H_0: PARAMETER=0	PROB > $\|T\|$
INTERCEPT	0.737	2.276	0.324	0.7478
RANGE	-0.0105	0.0177	-0.590	0.5585
QRANG	-0.00515	0.00337	-1.535	0.1326
BUYRANG	0.0156	0.00472	3.303	0.0020
SSFC	4.685	0.930	5.035	0.0001
QSSFC	-0.314	0.193	-1.629	0.1111
BUYSSFC	-0.275	0.234	-1.175	0.2466
COMP	1.998	1.088	1.838	0.0734
QCOMP	-0.243	0.185	-1.318	0.1948
BUYCOMP	0.0684	0.183	0.373	0.7110
COMPCTPR	-0.316	0.266	-1.187	0.2421
AURD	1.622	0.859	1.888	0.0662
QAURD	-0.214	0.142	-1.506	0.1397
BUYAURD	0.00671	0.259	0.026	0.9794
DEQ	-0.000233	.0000455	-5.123	0.0001
QDEQ	.00000521	.00000623	0.836	0.4081
BUYDEQ	.0000246	.00000987	2.489	0.0169
PCNTPROG	0.932	1.530	0.609	0.5459
QPCTPROG	-0.207	0.156	-1.328	0.1914
BYPCTPRG	0.170	0.0814	2.089	0.0429
CAPIP	5.550	1.268	4.377	0.0001
QCAPIP	-0.105	0.235	-0.448	0.6562
BUYCAPIP	-0.628	0.301	-2.089	0.0430
WPN	1.440	0.856	1.683	0.1000
QWPN	-0.537	0.252	-2.129	0.0393
BUYWPN	0.578	0.292	1.976	0.0549
RCF	-0.00384	0.00131	-2.937	0.0054
QRCF	.0000445	0.000285	0.156	0.8768
BUYRCF	0.000487	0.000312	1.563	0.1256
DODPCNT	5.218	0.977	5.341	0.0001
QPCNT	0.114	0.157	0.727	0.4712
BUYPCNT	-1.042	0.230	-4.522	0.0001
BLOGSALE	0.0625	0.415	0.151	0.8810
QBLS	-0.0448	0.0581	-0.771	0.4451
BUYBLS	0.0560	0.0855	0.655	0.5160
LCUMQ	1.436	0.664	2.162	0.0365
Q2	-0.185	0.0957	-1.928	0.0607
LBUY	0.287	0.761	0.378	0.7076
BUY2	-0.210	0.108	-1.947	0.0584

TABLE A–13

REGRESSION RESULTS:
Model 3, SPECIFICATION– A, DEP VARIABLE– $\ln P$

ANALYSIS OF VARIANCE				
SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE
Model	38	133.197	3.505	198.929
ERROR	41	0.722	0.0176	(0.0001)
C TOTAL	79	133.919		
R-SQUARE	0.9946	ADJ R-SQ	0.9896	

PARAMETER ESTIMATES				
VARIABLE	PARAMETER ESTIMATE	STANDARD ERROR	T FOR H_0: PARAMETER=0	PROB > $\|T\|$
INTERCEPT	0.217	2.131	0.102	0.9195
DIG	0.226	0.614	0.368	0.7150
QDIG	0.0207	0.176	0.118	0.9069
BUYDIG	-0.0324	0.226	-0.144	0.8865
RANGE	-0.00438	0.0198	-0.221	0.8259
QRANG	-0.00110	0.00371	-0.295	0.7693
BUYRANG	0.00950	0.00522	1.821	0.0760
SSFC	4.266	0.819	5.208	0.0001
QSSFC	-0.275	0.193	-1.425	0.1619
BUYSSFC	-0.268	0.245	-1.090	0.2820
COMP	2.250	1.019	2.207	0.0329
QCOMP	-0.201	0.194	-1.034	0.3070
BUYCOMP	-0.0253	0.194	-0.130	0.8968
COMPCTPR	-0.375	0.272	-1.376	0.1761
AURD	1.340	0.974	1.376	0.1762
QAURD	-0.329	0.142	-2.317	0.0256
BUYAURD	0.180	0.277	0.649	0.5200
DEQ	-0.000198	.0000404	-4.896	0.0001
QDEQ	.00000877	.00000710	1.234	0.2241
BUYDEQ	.0000157	.0000107	1.468	0.1496
PCNTPROG	-0.430	1.595	-0.269	0.7889
QPCTPROG	-0.0764	0.171	-0.446	0.6581
BYPCTPRG	0.180	0.102	1.773	0.0837
CAPIP	5.015	1.260	3.981	0.0003
QCAPIP	0.180	0.220	0.816	0.4194
BUYCAPIP	-0.883	0.304	-2.909	0.0058
WPN	2.686	1.473	1.823	0.0757
QWPN	-0.454	0.317	-1.432	0.1597
BUYWPN	0.452	0.385	1.174	0.2472
RCF	-0.00289	0.00141	-2.054	0.0464
QRCF	0.000114	0.000294	0.389	0.6992
BUYRCF	0.000279	0.000325	0.856	0.3970
DODPCNT	4.599	1.072	4.290	0.0001
QPCNT	0.0569	0.137	0.416	0.6797
BUYPCNT	-0.827	0.189	-4.373	0.0001
LCUMQ	1.084	0.585	1.854	0.0709
Q2	-0.154	0.0882	-1.751	0.0875
LBUY	0.306	0.698	0.438	0.6634
BUY2	-0.162	0.102	-1.593	0.1189

TABLE A–14

REGRESSION RESULTS:
Model 3, SPECIFICATION– A, DEP VARIABLE– ln P_{FY84}

ANALYSIS OF VARIANCE				
SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE
Model	38	128.882	3.392	206.184
ERROR	41	0.674	0.0164	(0.0001)
C TOTAL	79	129.557		
R-SQUARE	0.9948	ADJ R-SQ	0.9900	

PARAMETER ESTIMATES				
VARIABLE	PARAMETER ESTIMATE	STANDARD ERROR	T FOR H_0: PARAMETER=0	PROB > $\|T\|$
INTERCEPT	1.789	2.059	0.869	0.3900
DIG	-0.246	0.594	-0.414	0.6812
QDIG	0.122	0.170	0.719	0.4762
BUYDIG	-0.0719	0.218	-0.330	0.7432
RANGE	-0.00277	0.0191	-0.145	0.8856
QRANG	-0.00351	0.00359	-0.978	0.3339
BUYRANG	0.0119	0.00504	2.356	0.0233
SSFC	4.106	0.792	5.188	0.0001
QSSFC	-0.234	0.186	-1.253	0.2172
BUYSSFC	-0.283	0.237	-1.193	0.2396
COMP	1.850	0.985	1.878	0.0674
QCOMP	-0.173	0.188	-0.922	0.3622
BUYCOMP	0.00583	0.188	0.031	0.9754
COMPCTPR	-0.399	0.263	-1.517	0.1369
AURD	0.827	0.941	0.880	0.3842
QAURD	-0.274	0.137	-1.999	0.0523
BUYAURD	0.209	0.268	0.780	0.4400
DEQ	-0.000193	.0000390	-4.937	0.0001
QDEQ	.0000105	.00000686	1.536	0.1323
BUYDEQ	.0000129	.0000103	1.247	0.2194
PCNTPROG	-0.0709	1.541	-0.046	0.9635
QPCTPROG	-0.0894	0.166	-0.540	0.5924
BYPCTPRG	0.168	0.0983	1.706	0.0956
CAPIP	5.262	1.217	4.324	0.0001
QCAPIP	0.0285	0.213	0.134	0.8942
BUYCAPIP	-0.757	0.293	-2.579	0.0136
WPN	1.598	1.424	1.122	0.2683
QWPN	-0.584	0.306	-1.905	0.0638
BUYWPN	0.546	0.372	1.468	0.1498
RCF	-0.00279	0.00136	-2.050	0.0468
QRCF	0.000117	0.000284	0.413	0.6818
BUYRCF	0.000255	0.000314	0.812	0.4215
DODPCNT	4.323	1.036	4.174	0.0002
QPCNT	0.0312	0.132	0.236	0.8143
BUYPCNT	-0.761	0.183	-4.164	0.0002
LCUMQ	1.201	0.565	2.126	0.0396
Q2	-0.170	0.0852	-1.993	0.0529
LBUY	0.190	0.674	0.282	0.7792
BUY2	-0.156	0.0981	-1.591	0.1194

TABLE A–15

REGRESSION RESULTS:
Model 4, SPECIFICATION– A, DEP VARIABLE– ln P

ANALYSIS OF VARIANCE				
SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE
Model	35	133.158	3.805	220.006
ERROR	44	0.761	0.0173	(0.0001)
C TOTAL	79	133.919		
R-SQUARE	0.9943	ADJ R-SQ	0.9898	

PARAMETER ESTIMATES				
VARIABLE	PARAMETER ESTIMATE	STANDARD ERROR	T FOR H_0: PARAMETER=0	PROB > $\|T\|$
INTERCEPT	-0.333	1.994	-0.167	0.8680
RANGE	-0.00152	0.0162	-0.094	0.9258
QRANG	-0.00168	0.00314	-0.536	0.5944
BUYRANG	0.0102	0.00440	2.318	0.0252
SSFC	4.481	0.759	5.902	0.0001
QSSFC	-0.280	0.186	-1.504	0.1398
BUYSSFC	-0.304	0.236	-1.291	0.2036
COMP	2.481	0.958	2.591	0.0129
QCOMP	-0.281	0.182	-1.544	0.1299
BUYCOMP	0.0182	0.177	0.103	0.9186
COMPCTPR	-0.254	0.256	-0.992	0.3268
AURD	1.595	0.793	2.012	0.0504
QAURD	-0.250	0.130	-1.929	0.0602
BUYAURD	0.0328	0.237	0.139	0.8905
DEQ	-0.000209	.0000368	-5.677	0.0001
QDEQ	.00000781	.00000619	1.261	0.2138
BUYDEQ	.0000187	.00000888	2.109	0.0407
PCNTPROG	-0.135	1.478	-0.091	0.9278
QPCTPROG	-0.104	0.146	-0.711	0.4808
BYPCTPRG	0.161	0.0807	1.990	0.0529
CAPIP	5.157	1.195	4.314	0.0001
QCAPIP	0.151	0.217	0.694	0.4915
BUYCAPIP	-0.860	0.295	-2.912	0.0056
WPN	3.327	0.850	3.913	0.0003
QWPN	-0.495	0.252	-1.965	0.0557
BUYWPN	0.444	0.290	1.531	0.1328
RCF	-0.00263	0.00124	-2.131	0.0387
QRCF	.0000355	0.000286	0.124	0.9016
BUYRCF	0.000325	0.000305	1.068	0.2915
DODPCNT	4.638	0.880	5.270	0.0001
QPCNT	0.0911	0.132	0.689	0.4947
BUYPCNT	-0.886	0.168	-5.286	0.0001
LCUMQ	0.934	0.568	1.643	0.1075
Q2	-0.126	0.0850	-1.478	0.1465
LBUY	0.555	0.662	0.839	0.4062
BUY2	-0.201	0.0944	-2.125	0.0392

TABLE A-16

REGRESSION RESULTS:
Model 4, SPECIFICATION- A, DEP VARIABLE- ln P_{FY84}

ANALYSIS OF VARIANCE				
SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE
Model	35	128.824	3.681	220.959
ERROR	44	0.733	0.0167	(0.0001)
C TOTAL	79	129.557		
R-SQUARE	0.9943	ADJ R-SQ	0.9898	

PARAMETER ESTIMATES				
VARIABLE	PARAMETER ESTIMATE	STANDARD ERROR	T FOR H_0: PARAMETER=0	PROB > $\|T\|$
INTERCEPT	1.520	1.957	0.777	0.4414
RANGE	-0.0108	0.0159	-0.677	0.5020
QRANG	-0.00344	0.00308	-1.116	0.2705
BUYRANG	0.0135	0.00432	3.117	0.0032
SSFC	4.471	0.745	6.000	0.0001
QSSFC	-0.280	0.183	-1.535	0.1319
BUYSSFC	-0.298	0.231	-1.289	0.2042
COMP	2.179	0.940	2.318	0.0252
QCOMP	-0.262	0.179	-1.466	0.1498
BUYCOMP	0.0426	0.173	0.246	0.8069
COMPCTPR	-0.275	0.252	-1.094	0.2799
AURD	1.623	0.778	2.085	0.0429
QAURD	-0.181	0.127	-1.425	0.1613
BUYAURD	-0.0402	0.232	-0.173	0.8636
DEQ	-0.000219	.0000361	-6.056	0.0001
QDEQ	.00000676	.00000608	1.111	0.2725
BUYDEQ	.0000212	.00000871	2.439	0.0188
PCNTPROG	0.776	1.451	0.535	0.5954
QPCTPROG	-0.192	0.143	-1.339	0.1874
BYPCTPRG	0.159	0.0792	2.006	0.0511
CAPIP	5.187	1.173	4.422	0.0001
QCAPIP	0.00433	0.213	0.020	0.9839
BUYCAPIP	-0.708	0.290	-2.442	0.0187
WPN	1.297	0.835	1.554	0.1273
QWPN	-0.489	0.247	-1.977	0.0543
BUYWPN	0.533	0.285	1.870	0.0681
RCF	-0.00314	0.00121	-2.587	0.0130
QRCF	.0000260	0.000280	0.093	0.9264
BUYRCF	0.000397	0.000299	1.330	0.1905
DODPCNT	4.802	0.864	5.559	0.0001
QPCNT	0.0489	0.130	0.376	0.7086
BUYPCNT	-0.871	0.165	-5.292	0.0001
LCUMQ	1.062	0.558	1.904	0.0635
Q2	-0.142	0.0834	-1.703	0.0957
LBUY	0.438	0.650	0.674	0.5035
BUY2	-0.209	0.0927	-2.255	0.0291

TABLE B–1

ELASTICITIES FROM:
MODEL 1, SPECIFICATION– $\mathcal{L}$, DEP VARIABLE– $\ln P$

VARIABLE	EFFECT	STD. DEV.	T RATIO
DIG			
CASE 1	0.207	0.151	1.375
CASE 2	0.201	0.137	1.465
RANGE			
CASE 1	0.695	0.078	8.901
CASE 2	0.638	0.052	12.394
SSFC			
CASE 1	0.851	0.238	3.568
CASE 2	0.263	0.256	1.026
AURD			
CASE 1	0.229	0.119	1.927
CASE 2	0.035	0.152	0.231
DEQ			
CASE 1	-0.719	0.160	-4.484
CASE 2	-0.400	0.170	-2.349
CAPIP			
CASE 1	0.196	0.039	5.070
CASE 2	0.209	0.066	3.148
WPN			
CASE 1	1.481	0.180	8.219
CASE 2	1.496	0.173	8.650
RCF			
CASE 1	-0.194	0.110	-1.769
CASE 2	-0.030	0.079	-0.384
PERCENT DOD BUS			
CASE 1	-0.312	0.112	-2.785
CASE 2	-0.619	0.154	-4.023
BACKLOG/SALES RATIO			
CASE 1	0.149	0.099	1.501
CASE 2	0.146	0.116	1.258
ANNUAL BUY			
CASE 1	-0.165	0.177	-0.930
CASE 2	0.070	0.260	0.268
CUM. QUANTITY			
CASE 1	-0.164	0.199	-0.825
CASE 2	-0.200	0.255	-0.783
PERCENT PROGRAM COMPLETED			
CASE 1	0.095	0.085	1.116
CASE 2	0.073	0.067	1.084
COMPETITION			
CASE 1	0.657	0.219	2.998
CASE 2	0.370	0.277	1.335

TABLE B-2

ELASTICITIES FROM:
MODEL 1, SPECIFICATION- $\mathcal{L}$, DEP VARIABLE- $\ln P_{FY84}$

VARIABLE	EFFECT	STD. DEV.	T RATIO
DIG			
CASE 1	0.207	0.151	1.374
CASE 2	0.201	0.137	1.465
RANGE			
CASE 1	0.695	0.078	8.902
CASE 2	0.638	0.052	12.396
SSFC			
CASE 1	0.851	0.238	3.568
CASE 2	0.263	0.256	1.026
AURD			
CASE 1	0.229	0.119	1.927
CASE 2	0.035	0.152	0.231
DEQ			
CASE 1	-0.719	0.160	-4.484
CASE 2	-0.400	0.170	-2.349
CAPIP			
CASE 1	0.196	0.039	5.070
CASE 2	0.209	0.066	3.148
WPN			
CASE 1	0.481	0.180	2.670
CASE 2	0.496	0.173	2.870
CASHFLOW			
CASE 1	-0.194	0.110	-1.769
CASE 2	-0.030	0.079	-0.384
PERCENT DOD BUS			
CASE 1	-0.312	0.112	-2.785
CASE 2	-0.619	0.154	-4.023
BACKLOG/SALES RATIO			
CASE 1	0.149	0.099	1.501
CASE 2	0.146	0.116	1.258
ANNUAL BUY			
CASE 1	-0.165	0.177	-0.930
CASE 2	0.070	0.260	0.268
CUM. QUANTITY			
CASE 1	-0.164	0.199	-0.825
CASE 2	-0.200	0.255	-0.783
PERCENT PROGRAM COMPLETED			
CASE 1	0.095	0.085	1.116
CASE 2	0.073	0.067	1.084
COMPETITION			
CASE 1	0.657	0.219	2.998
CASE 2	0.370	0.277	1.335

TABLE B-3

ELASTICITIES FROM:
MODEL 2, SPECIFICATION- $\mathcal{L}$, DEP VARIABLE- $\ln P$

VARIABLE	EFFECT	STD. DEV.	T RATIO
RANGE			
CASE 1	0.772	0.061	12.716
CASE 2	0.693	0.044	15.577
SSFC			
CASE 1	0.816	0.234	3.494
CASE 2	0.186	0.250	0.746
AURD			
CASE 1	0.112	0.107	1.045
CASE 2	-0.102	0.134	-0.764
DEQ			
CASE 1	-0.732	0.144	-5.073
CASE 2	-0.399	0.162	-2.467
CAPIP			
CASE 1	0.224	0.036	6.279
CASE 2	0.245	0.064	3.845
WPN			
CASE 1	1.698	0.115	14.767
CASE 2	1.680	0.123	13.671
CASHFLOW			
CASE 1	-0.174	0.108	-1.613
CASE 2	-0.040	0.080	-0.497
PERCENT DOD BUS			
CASE 1	-0.331	0.114	-2.900
CASE 2	-0.630	0.151	-4.169
BACKLOG/SALES RATIO			
CASE 1	0.114	0.099	1.161
CASE 2	0.099	0.116	0.852
ANNUAL BUY			
CASE 1	-0.099	0.168	-0.591
CASE 2	0.189	0.240	0.788
CUM. QUANTITY			
CASE 1	-0.195	0.200	-0.977
CASE 2	-0.233	0.246	-0.946
PERCENT PROGRAM COMPLETED			
CASE 1	0.071	0.082	0.864
CASE 2	0.046	0.065	0.700
COMPETITION			
CASE 1	0.630	0.218	2.887
CASE 2	0.297	0.275	1.079

TABLE B–4

ELASTICITIES FROM:
MODEL 2, SPECIFICATION– $\mathcal{L}$, DEP VARIABLE– $\ln P_{FY84}$

VARIABLE	EFFECT	STD. DEV.	T RATIO
RANGE			
CASE 1	0.772	0.061	12.716
CASE 2	0.693	0.044	15.578
SSFC			
CASE 1	0.816	0.234	3.494
CASE 2	0.186	0.250	0.746
AURD			
CASE 1	0.112	0.107	1.045
CASE 2	-0.102	0.134	-0.764
DEQ			
CASE 1	-0.732	0.144	-5.073
CASE 2	-0.399	0.162	-2.467
CAPIP			
CASE 1	0.224	0.036	6.279
CASE 2	0.245	0.064	3.846
WPN			
CASE 1	0.698	0.115	6.068
CASE 2	0.680	0.123	5.531
CASHFLOW			
CASE 1	-0.174	0.108	-1.613
CASE 2	-0.040	0.080	-0.497
PERCENT DOD BUS			
CASE 1	-0.331	0.114	-2.900
CASE 2	-0.630	0.151	-4.169
BACKLOG/SALES RATIO			
CASE 1	0.114	0.099	1.161
CASE 2	0.099	0.116	0.852
ANNUAL BUY			
CASE 1	-0.099	0.168	-0.591
CASE 2	0.189	0.240	0.788
CUM. QUANTITY			
CASE 1	-0.195	0.200	-0.977
CASE 2	-0.233	0.246	-0.946
PERCENT PROGRAM COMPLETED			
CASE 1	0.071	0.082	0.864
CASE 2	0.046	0.065	0.700
COMPETITION			
CASE 1	0.630	0.218	2.887
CASE 2	0.297	0.275	1.080

TABLE B–5

ELASTICITIES FROM:
MODEL 3, SPECIFICATION– $\mathcal{L}$, DEP VARIABLE– $\ln P$

VARIABLE	EFFECT	STD. DEV.	T RATIO
DIG			
CASE 1	0.194	0.148	1.311
CASE 2	0.169	0.135	1.253
RANGE			
CASE 1	0.682	0.077	8.841
CASE 2	0.631	0.050	12.558
SSFC			
CASE 1	0.676	0.210	3.220
CASE 2	0.104	0.235	0.444
AURD			
CASE 1	0.122	0.096	1.275
CASE 2	-0.084	0.132	-0.639
DEQ			
CASE 1	-0.605	0.131	-4.611
CASE 2	-0.300	0.156	-1.924
CAPIP			
CASE 1	0.184	0.037	4.934
CASE 2	0.201	0.066	3.066
WPN			
CASE 1	1.466	0.179	8.181
CASE 2	1.488	0.172	8.644
CASHFLOW			
CASE 1	-0.192	0.109	-1.759
CASE 2	-0.056	0.076	-0.739
PERCENT DOD BUS			
CASE 1	-0.214	0.089	-2.404
CASE 2	-0.513	0.120	-4.277
ANNUAL BUY			
CASE 1	-0.136	0.170	-0.801
CASE 2	0.146	0.252	0.578
CUM. QUANTITY			
CASE 1	-0.176	0.195	-0.903
CASE 2	-0.220	0.247	-0.891
PERCENT PROGRAM COMPLETED			
CASE 1	0.098	0.082	1.199
CASE 2	0.067	0.065	1.023
COMPETITION			
CASE 1	0.478	0.184	2.598
CASE 2	0.170	0.247	0.688

TABLE B–6

ELASTICITIES FROM:
MODEL 3, SPECIFICATION– $\mathcal{L}$, DEP VARIABLE– $\ln P_{FY84}$

VARIABLE	EFFECT	STD. DEV.	T RATIO
DIG			
CASE 1	0.194	0.148	1.311
CASE 2	0.169	0.135	1.253
RANGE			
CASE 1	0.682	0.077	8.840
CASE 2	0.631	0.050	12.553
SSFC			
CASE 1	0.676	0.210	3.221
CASE 2	0.104	0.235	0.444
AURD			
CASE 1	0.122	0.096	1.276
CASE 2	-0.084	0.132	-0.639
DEQ			
CASE 1	-0.605	0.131	-4.612
CASE 2	-0.300	0.156	-1.924
CAPIP			
CASE 1	0.184	0.037	4.934
CASE 2	0.201	0.066	3.066
WPN			
CASE 1	0.466	0.179	2.599
CASE 2	0.488	0.172	2.834
CASHFLOW			
CASE 1	-0.192	0.109	-1.759
CASE 2	-0.056	0.076	-0.739
PERCENT DOD BUS			
CASE 1	-0.214	0.089	-2.404
CASE 2	-0.513	0.120	-4.277
ANNUAL BUY			
CASE 1	-0.136	0.170	-0.801
CASE 2	0.146	0.252	0.578
CUM. QUANTITY			
CASE 1	-0.176	0.195	-0.903
CASE 2	-0.220	0.247	-0.891
PERCENT PROGRAM COMPLETED			
CASE 1	0.098	0.082	1.199
CASE 2	0.067	0.065	1.024
COMPETITION			
CASE 1	0.478	0.184	2.598
CASE 2	0.170	0.247	0.688

TABLE B-7

ELASTICITIES FROM:
MODEL 4, SPECIFICATION- $\mathcal{L}$, DEP VARIABLE- $\ln P$

VARIABLE	EFFECT	STD. DEV.	T RATIO
RANGE			
CASE 1	0.761	0.059	12.969
CASE 2	0.683	0.041	16.496
SSFC			
CASE 1	0.682	0.206	3.307
CASE 2	0.082	0.228	0.357
AURD			
CASE 1	0.033	0.084	0.397
CASE 2	-0.179	0.117	-1.533
DEQ			
CASE 1	-0.639	0.117	-5.486
CASE 2	-0.323	0.147	-2.192
CAPIP			
CASE 1	0.213	0.034	6.302
CASE 2	0.238	0.062	3.854
WPN			
CASE 1	1.680	0.108	15.523
CASE 2	1.649	0.118	13.963
CASHFLOW			
CASE 1	-0.172	0.106	-1.621
CASE 2	-0.056	0.076	-0.741
PERCENT DOD BUS			
CASE 1	-0.255	0.088	-2.894
CASE 2	-0.546	0.114	-4.794
ANNUAL BUY			
CASE 1	-0.090	0.160	-0.565
CASE 2	0.214	0.230	0.929
CUM. QUANTITY			
CASE 1	-0.205	0.193	-1.060
CASE 2	-0.241	0.238	-1.010
PERCENT PROGRAM COMPLETED			
CASE 1	0.075	0.080	0.947
CASE 2	0.043	0.063	0.675
COMPETITION			
CASE 1	0.485	0.183	2.645
CASE 2	0.153	0.246	0.622

TABLE B–8

ELASTICITIES FROM:
MODEL 4, SPECIFICATION– $\mathcal{L}$, DEP VARIABLE– $\ln P_{FY84}$

VARIABLE	EFFECT	STD. DEV.	T RATIO
RANGE			
CASE 1	0.761	0.059	12.966
CASE 2	0.683	0.041	16.485
SSFC			
CASE 1	0.682	0.206	3.307
CASE 2	0.082	0.228	0.357
AURD			
CASE 1	0.033	0.084	0.397
CASE 2	-0.179	0.117	-1.533
DEQ			
CASE 1	-0.639	0.116	-5.486
CASE 2	-0.323	0.147	-2.192
CAPIP			
CASE 1	0.213	0.034	6.302
CASE 2	0.238	0.062	3.854
WPN			
CASE 1	0.680	0.108	6.286
CASE 2	0.649	0.118	5.497
CASHFLOW			
CASE 1	-0.172	0.106	-1.621
CASE 2	-0.056	0.076	-0.741
PERCENT DOD BUS			
CASE 1	-0.255	0.088	-2.894
CASE 2	-0.546	0.114	-4.794
ANNUAL BUY			
CASE 1	-0.090	0.160	-0.565
CASE 2	0.214	0.230	0.929
CUM. QUANTITY			
CASE 1	-0.205	0.193	-1.060
CASE 2	-0.241	0.238	-1.010
PERCENT PROGRAM COMPLETED			
CASE 1	0.075	0.080	0.947
CASE 2	0.043	0.063	0.675
COMPETITION			
CASE 1	0.485	0.183	2.645
CASE 2	0.153	0.246	0.622

TABLE B–9

ELASTICITIES FROM:
MODEL 1, SPECIFICATION– A, DEP VARIABLE ln P

VARIABLE	EFFECT	STD. DEV.	T RATIO
DIG			
CASE 1	0.179	0.137	1.303
CASE 2	0.184	0.131	1.401
RANGE			
CASE 1	1.737	0.134	12.957
CASE 2	0.833	0.063	13.276
SSFC			
CASE 1	0.642	0.216	2.967
CASE 2	0.263	0.231	1.141
AURD			
CASE 1	0.117	0.135	0.866
CASE 2	0.036	0.235	0.152
DEQ			
CASE 1	-0.319	0.074	-4.312
CASE 2	-0.329	0.159	-2.075
CAPIP			
CASE 1	0.131	0.033	3.954
CASE 2	0.054	0.057	0.960
WPN			
CASE 1	1.887	0.234	8.059
CASE 2	1.404	0.170	8.240
CASHFLOW			
CASE 1	-0.109	0.116	-0.944
CASE 2	0.040	0.081	0.495
PERCENT DOD BUS			
CASE 1	-0.301	0.115	-2.61
CASE 2	-0.609	0.155	-3.93
BACKLOG/SALES RATIO			
CASE 1	0.147	0.087	1.688
CASE 2	0.171	0.112	1.528
ANNUAL BUY			
CASE 1	-0.118	0.139	-0.853
CASE 2	-0.335	0.208	-1.613
CUM. QUANTITY			
CASE 1	-0.402	0.171	-2.350
CASE 2	-0.365	0.221	-1.652
PERCENT PROGRAM COMPLETED			
CASE 1	0.057	0.078	0.729
CASE 2	0.072	0.062	1.151
COMPETITION			
CASE 1	0.645	0.190	3.396
CASE 2	0.528	0.255	2.069

TABLE B–10

ELASTICITIES FROM:
MODEL 1, SPECIFICATION– A, DEP VARIABLE– $\ln P_{FY84}$

VARIABLE	EFFECT	STD. DEV.	T RATIO
DIG			
CASE 1	0.197	0.132	1.491
CASE 2	0.257	0.127	2.032
RANGE			
CASE 1	1.711	0.129	13.229
CASE 2	0.814	0.061	13.454
SSFC			
CASE 1	0.701	0.209	3.361
CASE 2	0.326	0.222	1.467
AURD			
CASE 1	0.192	0.131	1.468
CASE 2	0.170	0.227	0.752
DEQ			
CASE 1	-0.324	0.071 -4.539	
CASE 2	-0.344	0.153 -2.245	
CAPIP			
CASE 1	0.122	0.032 3.828	
CASE 2	0.037	0.055 0.673	
WPN			
CASE 1	0.695	0.226	3.077
CASE 2	0.478	0.164	2.906
CASHFLOW			
CASE 1	-0.113	0.112	-1.007
CASE 2	0.027	0.079	0.350
PERCENT DOD BUS			
CASE 1	-0.314	0.111	-2.833
CASE 2	-0.591	0.150	-3.941
BACKLOG/SALES RATIO			
CASE 1	0.145	0.084	1.725
CASE 2	0.147	0.108	1.358
ANNUAL BUY			
CASE 1	-0.091	0.134	-0.682
CASE 2	-0.359	0.201	-1.788
CUM. QUANTITY			
CASE 1	-0.458	0.165	-2.770
CASE 2	-0.433	0.213	-2.031
PERCENT PROGRAM COMPLETED			
CASE 1	0.086	0.076	1.133
CASE 2	0.101	0.060	1.673
COMPETITION			
CASE 1	0.661	0.183	3.606
CASE 2	0.572	0.246	2.322

TABLE B-11

ELASTICITIES FROM:
MODEL 2, SPECIFICATION- *A*, DEP VARIABLE ln *P*

VARIABLE	EFFECT	STD. DEV.	T RATIO
RANGE			
CASE 1	1.840	0.104	17.605
CASE 2	0.879	0.054	16.288
SSFC			
CASE 1	0.589	0.206	2.861
CASE 2	0.166	0.217	0.764
AURD			
CASE 1	0.010	0.115	0.091
CASE 2	-0.136	0.199	-0.681
DEQ			
CASE 1	-0.313	0.072	-4.348
CASE 2	-0.282	0.153	-1.839
CAPIP			
CASE 1	0.143	0.030	4.751
CASE 2	0.068	0.054	1.245
WPN			
CASE 1	2.130	0.155	13.765
CASE 2	1.582	0.113	14.048
CASHFLOW			
CASE 1	-0.128	0.104	-1.225
CASE 2	0.019	0.079	0.239
PERCENT DOD BUS			
CASE 1	-0.341	0.111	-3.07
CASE 2	-0.656	0.145	-4.53
BACKLOG/SALES RATIO			
CASE 1	0.141	0.085	1.662
CASE 2	0.151	0.109	1.391
ANNUAL BUY			
CASE 1	-0.055	0.128	-0.426
CASE 2	-0.311	0.189	-1.647
CUM. QUANTITY			
CASE 1	-0.436	0.167	-2.607
CASE 2	-0.337	0.206	-1.631
PERCENT PROGRAM COMPLETED			
CASE 1	0.049	0.075	0.649
CASE 2	0.056	0.061	0.933
COMPETITION			
CASE 1	0.592	0.179	3.309
CASE 2	0.434	0.244	1.778

TABLE B-12

ELASTICITIES FROM:
MODEL 2, SPECIFICATION– A, DEP VARIABLE– $\ln P_{FY84}$

VARIABLE	EFFECT	STD. DEV.	T RATIO
RANGE			
CASE 1	1.784	0.103	17.276
CASE 2	0.873	0.053	16.362
SSFC			
CASE 1	0.592	0.203	2.913
CASE 2	0.184	0.215	0.856
AURD			
CASE 1	0.074	0.114	0.653
CASE 2	-0.069	0.197	-0.352
DEQ			
CASE 1	-0.315	0.071	-4.433
CASE 2	-0.280	0.151	-1.850
CAPIP			
CASE 1	0.128	0.030	4.279
CASE 2	0.051	0.054	0.948
WPN			
CASE 1	0.947	0.153	6.189
CASE 2	0.730	0.111	6.561
CASHFLOW			
CASE 1	-0.180	0.103	-1.745
CASE 2	-0.008	0.078	-0.104
PERCENT DOD BUS			
CASE 1	-0.360	0.110	-3.271
CASE 2	-0.684	0.144	-4.747
BACKLOG/SALES RATIO			
CASE 1	0.123	0.084	1.465
CASE 2	0.143	0.107	1.332
ANNUAL BUY			
CASE 1	-0.001	0.127	-0.010
CASE 2	-0.339	0.187	-1.817
CUM. QUANTITY			
CASE 1	-0.517	0.165	-3.129
CASE 2	-0.398	0.204	-1.950
PERCENT PROGRAM COMPLETED			
CASE 1	0.096	0.074	1.299
CASE 2	0.091	0.060	1.521
COMPETITION			
CASE 1	0.562	0.177	3.180
CASE 2	0.440	0.241	1.825

TABLE B–13

ELASTICITIES FROM:
MODEL 3, SPECIFICATION– *A*, DEP VARIABLE ln *P*

VARIABLE	EFFECT	STD. DEV.	T RATIO
DIG			
CASE 1	0.172	0.133	1.292
CASE 2	0.164	0.131	1.258
RANGE			
CASE 1	1.688	0.124	13.605
CASE 2	0.811	0.060	13.494
SSFC			
CASE 1	0.510	0.196	2.596
CASE 2	0.134	0.216	0.619
AURD			
CASE 1	0.045	0.129	0.350
CASE 2	-0.058	0.226	-0.258
DEQ			
CASE 1	-0.275	0.064	-4.301
CASE 2	-0.261	0.151	-1.732
CAPIP			
CASE 1	0.119	0.031	3.891
CASE 2	0.045	0.056	0.799
WPN			
CASE 1	1.827	0.228	8.012
CASE 2	1.374	0.169	8.116
CASHFLOW			
CASE 1	-0.119	0.113	-1.053
CASE 2	0.005	0.078	0.065
PERCENT DOD BUS			
CASE 1	-0.161	0.084	-1.91
CASE 2	-0.441	0.112	-3.94
ANNUAL BUY			
CASE 1	-0.103	0.138	-0.744
CASE 2	-0.286	0.206	-1.389
CUM. QUANTITY			
CASE 1	-0.343	0.164	-2.092
CASE 2	-0.304	0.209	-1.455
PERCENT PROGRAM COMPLETED			
CASE 1	0.031	0.074	0.420
CASE 2	0.046	0.060	0.765
COMPETITION			
CASE 1	0.519	0.167	3.106
CASE 2	0.362	0.231	1.564

TABLE B-14

ELASTICITIES FROM:
MODEL 3, SPECIFICATION- A, DEP VARIABLE- $\ln P_{FY84}$

VARIABLE	EFFECT	STD. DEV.	T RATIO
DIG			
CASE 1	0.202	0.129	1.569
CASE 2	0.237	0.126	1.879
RANGE			
CASE 1	1.649	0.120	13.763
CASE 2	0.794	0.058	13.678
SSFC			
CASE 1	0.558	0.190	2.936
CASE 2	0.199	0.209	0.953
AURD			
CASE 1	0.124	0.125	0.996
CASE 2	0.078	0.219	0.359
DEQ			
CASE 1	-0.273	0.062	-4.416
CASE 2	-0.269	0.146	-1.846
CAPIP			
CASE 1	0.108	0.030	3.641
CASE 2	0.027	0.054	0.498
WPN			
CASE 1	0.623	0.220	2.829
CASE 2	0.453	0.164	2.767
CASHFLOW			
CASE 1	-0.130	0.109	-1.195
CASE 2	-0.009	0.075	-0.114
PERCENT DOD BUS			
CASE 1	-0.188	0.081	-2.319
CASE 2	-0.450	0.108	-4.170
ANNUAL BUY			
CASE 1	-0.079	0.133	-0.591
CASE 2	-0.315	0.199	-1.585
CUM. QUANTITY			
CASE 1	-0.408	0.158	-2.573
CASE 2	-0.384	0.202	-1.902
PERCENT PROGRAM COMPLETED			
CASE 1	0.067	0.072	0.938
CASE 2	0.078	0.058	1.359
COMPETITION			
CASE 1	0.521	0.161	3.230
CASE 2	0.405	0.224	1.813

TABLE B-15

ELASTICITIES FROM:
MODEL 4, SPECIFICATION- A, DEP VARIABLE $\ln P$

VARIABLE	EFFECT	STD. DEV.	T RATIO
RANGE			
CASE 1	1.790	0.100	17.904
CASE 2	0.856	0.050	16.996
SSFC			
CASE 1	0.456	0.188	2.426
CASE 2	0.051	0.204	0.249
AURD			
CASE 1	-0.055	0.108	-0.510
CASE 2	-0.206	0.191	-1.082
DEQ			
CASE 1	-0.263	0.061	-4.317
CASE 2	-0.213	0.145	-1.463
CAPIP			
CASE 1	0.132	0.029	4.574
CASE 2	0.059	0.053	1.112
WPN			
CASE 1	2.066	0.149	13.828
CASE 2	1.533	0.109	14.105
CASHFLOW			
CASE 1	-0.134	0.103	-1.299
CASE 2	-0.014	0.075	-0.190
PERCENT DOD BUS			
CASE 1	-0.211	0.076	-2.78
CASE 2	-0.497	0.099	-5.02
ANNUAL BUY			
CASE 1	-0.048	0.128	-0.376
CASE 2	-0.280	0.185	-1.509
CUM. QUANTITY			
CASE 1	-0.379	0.160	-2.375
CASE 2	-0.280	0.195	-1.436
PERCENT PROGRAM COMPLETED			
CASE 1	0.024	0.072	0.329
CASE 2	0.032	0.058	0.544
COMPETITION			
CASE 1	0.457	0.154	2.966
CASE 2	0.275	0.220	1.248

TABLE B-16

ELASTICITIES FROM:
MODEL 4, SPECIFICATION- 4, DEP VARIABLE- $\ln P_{FY84}$

VARIABLE	EFFECT	STD. DEV.	T RATIO
RANGE			
CASE 1	1.740	0.098	17.731
CASE 2	0.850	0.049	17.198
SSFC			
CASE 1	0.479	0.184	2.600
CASE 2	0.078	0.200	0.391
AURD			
CASE 1	0.017	0.106	0.158
CASE 2	-0.137	0.187	-0.732
DEQ			
CASE 1	-0.275	0.060	-4.609
CASE 2	-0.221	0.143	-1.546
CAPIP			
CASE 1	0.117	0.028	4.148
CASE 2	0.042	0.052	0.807
WPN			
CASE 1	0.887	0.147	6.053
CASE 2	0.687	0.107	6.439
CASHFLOW			
CASE 1	-0.185	0.101	-1.836
CASE 2	-0.038	0.074	-0.521
PERCENT DOD BUS			
CASE 1	-0.244	0.075	-3.249
CASE 2	-0.537	0.098	-5.476
ANNUAL BUY			
CASE 1	0.007	0.125	0.056
CASE 2	-0.307	0.182	-1.688
CUM. QUANTITY			
CASE 1	-0.461	0.157	-2.941
CASE 2	-0.339	0.191	-1.774
PERCENT PROGRAM COMPLETED			
CASE 1	0.072	0.071	1.019
CASE 2	0.068	0.057	1.188
COMPETITION			
CASE 1	0.448	0.151	2.965
CASE 2	0.296	0.216	1.370